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Mapping Fear and Hope in HPV Vaccine Communication on Sina Weibo: Topic Modeling and Content Analysis

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Abstract

HPV vaccines became available in mainland China in 2016, yet concerns surrounding HPV vaccination have continued to feature prominently in public discourse. Against this background, this study examined how HPV and HPV vaccination are discussed on Sina Weibo and how threat- and efficacy-related message components are represented within this discourse. Drawing on the Extended Parallel Process Model (EPPM), this study analyzed 219,068 posts on Sina Weibo published between 2018 and 2024 using topic modeling and theory-guided content analysis. Topic modeling revealed a substantial increase in HPV-related discussions over the study period and identified five prominent themes: health behaviors, HPV vaccination, cervical cancer prevention, nine-valent HPV vaccine appointment scheduling, and HPV infection. Content analysis further revealed an imbalance between threat and efficacy components in fear-appeal messages. Efficacy information occurred more frequently than threat information, with self-efficacy appearing most frequently, followed by response efficacy, susceptibility, and severity. Spearman correlation analyses showed that severity and self-efficacy were positively associated with the number of user forwards, whereas susceptibility and response efficacy were not significantly associated with forwarding activity in the reported analysis. These findings extend the application of the EPPM to naturally occurring social media communication by demonstrating how threat and efficacy components are unevenly represented and differently associated with observable user engagement. The study also highlights the importance of designing HPV communication that balances information about health threats with clear and actionable efficacy information.

Keywords: HPV, HPV vaccine, Sina Weibo, topic modeling, content analysis

1. INTRODUCTION

Cervical cancer remains a substantial public health challenge worldwide, and persistent infection with high-risk human papillomavirus (HPV) is its principal cause. The disease is largely preventable through vaccination against HPV, appropriate cervical screening, and timely treatment of precancerous lesions, making access to prevention services central to reducing its burden [1]. Recognizing this preventability, the World Health Organization established the 90–70–90 targets for 2030: fully vaccinating 90% of girls against HPV by age 15, screening 70% of women by ages 35 and 45, and treating 90% of women identified with cervical disease [2]. In China, the context of this study, cervical cancer continues to pose a substantial health challenge, prompting increasingly systematic efforts to strengthen vaccination, screening, and treatment. The National Health Commission reported that Guangdong, Hainan, Fujian, and several cities had introduced free HPV vaccination policies for eligible girls [3]. These local initiatives informed broader efforts to expand access, including vaccination pilots and support for resource-constrained communities. A nationwide post-marketing survey also identified gaps in HPV-related knowledge, attitudes, and vaccination practices [4], underscoring the continuing importance of public understanding, accessible services, and communication surrounding HPV prevention.

To communicate the potential risks associated with HPV, the Chinese government has actively disseminated information about HPV vaccines through both traditional and social media channels, and Sina Weibo has become a large-scale venue for observing HPV vaccination discourse in China [5, 6]. In this regard, researchers have used Weibo data to study public reactions to HPV policy changes, barriers, attitudes, and topic evolution over multi-year periods [7–9]. Government agencies, media organizations, health professionals, and ordinary users all contribute to these discussions, but they emphasize different issues [10]. In response, HPV discussions on Weibo include recurring topics such as HPV risks, guidance information, policy, advertising, scandals, and personal experience sharing [11, 12]. Some posts focus on infection risk and consequences by linking HPV vaccination to cervical cancer and other major cancers, while other posts foreground efficacy by emphasizing vaccination benefits, prevention, checkups, and practical guidance for obtaining vaccination [6, 10]. Safety and side-effect concerns also appear in Chinese HPV discourse, though some studies find that these topics receive less attention than access or cancer framing [5, 10]. This suggests that the information environment is not uniform, because different user groups and platforms stress different aspects of HPV vaccination. These differences matter because the way HPV is represented can make particular dimensions of risk and prevention more salient in Chinese public discourse.

Despite the growing importance of social media in HPV communication, two related questions remain insufficiently understood. First, although earlier studies have examined the thematic structure of HPV and HPV vaccine discussions on Sina Weibo, further work can clarify how dominant topics and their temporal patterns relate to the threat and efficacy components of messages [6, 9, 11]. Examining these patterns is important not only for understanding how HPV information circulates, but also for understanding what information users are likely to encounter on the platform. Second, less attention has been given to the persuasive structure of these naturally occurring messages than to experimental tests of message effects [13–15]. One direct Weibo content analysis applied EPPM to ask how messages portray susceptibility, severity, self-efficacy, and response efficacy, showing that this line of work exists but remains limited [5]. That study identified a gendered representation of HPV risk and vaccination, with considerable emphasis on women and cervical cancer and uneven coverage of other prevention-related information. Its findings demonstrate the value of examining the individual components of messages rather than assuming that the information environment presents a comprehensive account of HPV prevention. This supports the claim that naturally occurring HPV messages vary in how they configure threat and efficacy rather than presenting a single balanced persuasive pattern. From the perspective of the Extended Parallel Process Model (EPPM), balancing threat and efficacy is essential. Specifically, threat information establishes the seriousness of the risk, whereas efficacy information provides a pathway through which individuals may perceive that the threat can be controlled. In this sense, HPV communication may encompass not only fear-inducing representations of health risk but also efficacy-oriented messages that offer the possibility of protection and, theoretically, hope.

Against this background, the present study examines HPV and HPV vaccine communication on Sina Weibo at two complementary levels. First, using topic modeling on a large-scale corpus of Weibo posts, it identifies the dominant themes in HPV-related discourse and examines how their prevalence changes over time. Second, drawing on the EPPM, the study uses content analysis to examine how threat and efficacy components are represented in HPV vaccine-related messages and whether these message characteristics are associated with user engagement. By integrating computational topic modeling with theory-driven content analysis, the study moves beyond examining the diffusion of HPV information to investigate both the substantive information environment and the persuasive architecture of HPV communication on Chinese social media.

2. LITERATURE REVIEW

Social media has become a major platform for public health communication, allowing health authorities, healthcare organizations, and members of the public to disseminate, obtain, and exchange health information rapidly [16]. Unlike traditional mass media, social media combines information dissemination with interactivity, enabling users not only to access health information but also to comment on, share, and participate in discussions surrounding health issues [17]. These affordances can increase health awareness and facilitate preventive health behaviors [16]. However, the relatively open nature of social media also allows inaccurate or misleading health information to circulate widely, potentially contributing to misperceptions, vaccine hesitancy, and problematic health-related decisions [18]. These opportunities and challenges are particularly relevant to HPV communication.

Media coverage constitutes an important source through which the public develops knowledge and perceptions of HPV infection, cervical cancer, and HPV vaccination [19, 20]. The increasing use of social media has further expanded this information environment by allowing healthcare organizations, government agencies, media organizations, and individual users to communicate about HPV and cervical cancer prevention [21]. However, media information is not necessarily comprehensive or balanced. Media coverage often selectively emphasizes certain aspects of a health issue while giving less attention to others, thereby shaping which risks, benefits, and preventive options become most salient to audiences [22–24]. In the context of HPV vaccination, for example, messages may disproportionately highlight vaccine side effects, safety controversies, or individual adverse experiences while providing comparatively limited information about vaccine effectiveness, the risks associated with HPV infection, or the broader benefits of cervical cancer prevention [20, 22, 25]. Conversely, messages that strongly promote vaccination without adequately addressing public concerns regarding safety, accessibility, or uncertainty may also be perceived as incomplete or unconvincing [19, 26]. This uneven representation is crucial because audiences frequently rely on media cues to assess the severity of HPV-related health risks and evaluate the benefits and potential costs of vaccination. Consequently, selective or imbalanced coverage may produce distorted perceptions of vaccine safety and effectiveness and contribute to uncertainty, polarized attitudes, or vaccine hesitancy [27].

Social media has become an increasingly important component of this environment. Jiang et al. [11], for example, found that social media serves as an important source through which Chinese users encounter and engage with HPV vaccination information, with potential consequences for health knowledge, attitudes, and vaccination intentions. However, the informational value of social media is accompanied by concerns about credibility. Misinformation and deceptive or unsubstantiated claims about HPV vaccination can coexist with scientifically accurate health information, potentially amplifying uncertainty about HPV infection and vaccine safety [28, 29]. Social media should therefore be understood not simply as a health-promotion channel, but as an information environment in which competing representations of disease, vaccination, risk, prevention, and personal experience circulate simultaneously. In China, Sina Weibo is particularly important because it provides a large-scale public communication space in which health authorities, media organizations, commercial actors, and ordinary users participate in health-related discussions [30]. Previous research on Weibo has examined the dissemination and diffusion of health information, including message virality, user interaction, and the role of social-network characteristics in shaping information spread [31, 32]. These studies provide valuable insights into how health information circulates. However, understanding the information environment also requires examining what is being communicated.

Existing research suggests that HPV information may vary considerably in its thematic coverage. Studies of traditional Chinese media have identified important informational omissions. For example, Li et al. [33] found that fewer than half of the newspaper articles examined mentioned the association between HPV and male-related cancers or genital warts, while still fewer addressed sexual transmission. Research on Chinese social media has similarly suggested that, although online platforms allow more extensive discussion of HPV-related issues, their coverage may remain uneven or incomplete. For example, Li and Zheng [34] found that discussions concentrated heavily on the relationship between HPV and cervical cancer while providing substantially less attention to other HPV-related conditions in Zhihu. These findings point to an important distinction between information diffusion and information composition.

Despite increasing scholarly attention to HPV communication, relatively limited research has systematically mapped the large-scale thematic structure of HPV and HPV vaccine discussions on Sina Weibo. Existing studies provide important evidence on HPV knowledge, information coverage, misinformation, and individual responses, but they offer less insight into which topics dominate Weibo discourse and whether their prominence changes over time. Examining temporal change is particularly important because HPV communication occurs within a changing informational environment shaped by vaccine availability, public-health initiatives, media attention, and ongoing public discussion. Accordingly, this study first identifies the major themes embedded within HPV-related Weibo messages and examines their temporal distribution.

RQ1: What are the dominant themes in Sina Weibo discussions of HPV and HPV vaccination, and what is the relative prevalence of these themes?

RQ2: How has the prevalence of HPV- and HPV vaccine-related themes on Sina Weibo changed over time?

Beyond the thematic content of HPV discussions, the persuasive structure of health messages is also important. Health communication frequently employs emotionally evocative messages to draw attention to health threats and encourage preventive action. Among these strategies, fear appeals seek to motivate protective behavior by communicating potentially severe and personally significant outcomes associated with a health threat [35]. Fear appeals have been employed across numerous health contexts, including HIV prevention, breast self-examination, physical activity, cancer prevention, and vaccination [13, 36–41].

The Extended Parallel Process Model (EPPM; [42]) provides one of the most influential theoretical explanations of how individuals respond to fear-arousing health messages. The model proposes that message responses depend primarily on evaluations of threat and efficacy. Perceived threat consists of two dimensions: perceived severity, referring to beliefs about the seriousness of a health threat, and perceived susceptibility, referring to beliefs about one's likelihood of experiencing that threat. Perceived efficacy likewise comprises two dimensions: response efficacy, or the belief that the recommended response can effectively reduce the threat, and self-efficacy, or confidence in one's ability to perform the recommended response [42, 43]. Within the EPPM, threat and efficacy operate jointly rather than independently [42]. When perceived threat is sufficiently high, individuals become motivated to respond to the message [44, 45]. When high threat is accompanied by strong efficacy beliefs, individuals are expected to engage in danger-control processes directing their attention toward controlling the threat by accepting the recommended action [42, 46]. These responses may include favorable changes in beliefs, attitudes, behavioral intentions, and protective behavior [47]. In contrast, high threat combined with insufficient efficacy may trigger fear-control processes, in which individuals attempt to regulate their emotional discomfort rather than address the threat itself [45, 46]. The responses can manifest as defensive avoidance, message rejection, information minimization, or perceptual distancing [43, 47, 48]. When perceived threat is low, individuals may have little motivation to process or act upon the message.

A substantial body of empirical research supports the importance of threat and efficacy in persuasive health communication. Meta-analytic evidence indicates that appropriately constructed fear appeals can promote protective intentions and behaviors, particularly when messages provide recipients with effective and feasible means of responding to the threat [49, 50]. Applications of the EPPM have similarly demonstrated the relevance of threat and efficacy across health and risk contexts. For example, EPPM-based studies have examined HIV-related risk reduction [40], breast self-examination [38], skin cancer prevention [51], climate-change communication [52], and HPV vaccination [13, 37, 41]. Although the EPPM has traditionally emphasized fear, more recent scholarship suggests that the emotional dynamics of fear appeals may be more complex [53, 54]. Fear is linked to threat appraisal, especially severity and susceptibility, whereas efficacy information supports the belief that the recommended response is effective and feasible, which can shift people toward adaptive action [43, 47, 50]. Nabi and Myrick [55], therefore, proposed that efficacy information may elicit hope, an emotion associated with the possibility of achieving a desired future outcome despite the presence of a threat. Their findings showed that hope contributed to behavioral intentions even when the conventional cognitive components of fear appeals were taken into account.

This perspective is particularly relevant to vaccination communication. Vaccine messages can combine information about infection risk with information about vaccine effectiveness. In this pattern, threat content tends to heighten fear and attention to vulnerability, whereas efficacy content tends to increase beliefs that vaccination can work and can foster hope, acceptance, and protective intention [56–58]. Research on fear–hope sequencing in MMR vaccination messages and on sensationalistic health news suggests that emotional framing and sequencing warrant attention, while findings should be interpreted within their specific populations and outcome measures [59, 60]. In summary, the evidence suggests that effective vaccine communication does not rely on fear alone. In fact, messages are more persuasive when they pair clear information about risk with credible, actionable efficacy cues that can sustain hope, support adaptive processing, and guide audiences toward vaccination, although these effects vary across vaccines, populations, and message contexts.

Most EPPM research has examined the psychological effects of experimentally manipulated messages or measured individuals' perceptions through survey research [42, 43, 54, 61]. The model, however, can also provide a conceptual framework for examining the content structure of naturally occurring health messages [62, 63]. This approach shifts the analytical question from how individuals perceive experimentally constructed threat and efficacy to whether and how these persuasive components appear in actual media discourse [64, 65]. Previous content-analytic research demonstrates the value of this approach. Turner et al. [66], for example, identified imbalances between threat and efficacy information in crisis communication, suggesting that messages heavily emphasizing threats without sufficiently communicating effective responses may be poorly structured from an EPPM perspective. Media representations that strongly foreground threatening consequences may heighten the salience of risk, whereas efficacy information may provide audiences with actionable means of responding to that risk [67]. Examining the relative presence of these components therefore offers insight into the persuasive architecture of health messages, independent of directly measuring audience perceptions.

In Sina Weibo discussions of HPV vaccination, some posts foreground threat by emphasizing HPV infection, personal susceptibility, or the health consequences of infection, including cervical cancer [5, 11]. Other posts emphasize efficacy by

emphasizing vaccine benefits, practical guidance for prevention, screening-related information, or users' ability to obtain vaccination [5, 10]. These elements do not always appear in the same proportion. Some Weibo messages include both threat and efficacy, whereas others give these components unequal attention [5]. Related research has also examined health anxiety and collective sense-making in Weibo discussions [68]. From an EPPM perspective, these configurations are substantively different because threat and efficacy are distinct message components that can be identified separately in social media content and are theorized to shape communication effects in different ways. Furthermore, social media also makes it possible to test whether particular message characteristics are associated with observable user engagement, because studies routinely analyze likes, comments, reposts, or shares as outcomes linked to message content [69–71]. In health communication specifically, threat and efficacy cues, warning elements, reassurance, and other content features have all been examined in relation to engagement metrics [69, 72]. Experimental research on comments addresses a different outcome: Long et al. [73] examined HPV vaccination intentions and self-efficacy after exposure to comments that varied in valence and argument quality. Likes, comments, and reposts are best treated as behavioral indicators of interaction, not automatic evidence of persuasion or acceptance [74]. Reviews of social-media health campaigns note that engagement is measured far more often than downstream outcomes, and that researchers often cannot determine from engagement alone whether campaign objectives were achieved [74].

Despite the extensive literature on fear appeals and a growing body of research on HPV vaccination communication, considerably less is known about how threat and efficacy are structurally represented in naturally occurring HPV vaccine discussions on Chinese social media, let alone about whether these message components are associated with variations in user engagement. Addressing these questions extends EPPM-informed research from audience-level responses to the analysis of naturally occurring digital health communication and allows the present study to connect persuasive message characteristics with observable patterns of online interaction. Therefore, the following research questions are proposed:

RQ3: How are threat and efficacy components represented in HPV vaccine-related messages on Sina Weibo?

RQ4: How are threat and efficacy components in HPV vaccine-related messages associated with user engagement on Sina Weibo?

3. METHOD

Sina Weibo was selected for this study because it is one of China's most popular social media platforms, with 573 million monthly active users and 249 million average daily active users in December 2021 [75]. As a microblogging service similar to Twitter, Weibo has been widely adopted, with mobile users accounting for approximately 95% of monthly active users in the same reporting period. This platform provides an extensive base for public discourse, making it an ideal source for data collection. The sampling frame for this study spans from June 30, 2018, to June 30, 2024, covering a period of expanding HPV vaccine availability and sustained public discussion in China. Using Python, we developed a crawler to extract relevant data from Sina Weibo, focusing on posts containing the keywords "HPV" and "HPV vaccine." Prior to conducting topic modeling, it is essential to clean the text corpus by removing undesirable components, as the input vocabulary significantly affects the reliability, interpretability, and validity of the topic model [76]. Therefore, we preprocessed the text and removed irrelevant posts from the entire dataset. This process yielded a total of 219,068 valid posts, including metadata such as username, post content, location, categorization, forwards, comments, likes, timestamps, and the tool used to post.

Latent Dirichlet Allocation (LDA) was used for topic modeling. LDA is an unsupervised machine learning technique that identifies hidden topic structures within large text datasets by organizing words, topics, and documents into a three-layer structure. This method transforms textual data into numerical representations using word-frequency vectors derived from text preprocessing, enabling topic classification based on statistical word-frequency distributions.

The Latent Dirichlet Allocation (LDA) model generates multilayer probability distributions of topic word composition and document topic composition, thereby enabling the identification of key themes from large-scale textual data [11]. After collecting 219,068 posts related to "HPV" and "HPV vaccine," the data were first converted into plain text and preprocessed by removing duplicate records, punctuation, numbers, hyperlinks, and stop words. Chinese word segmentation was then performed, and only words with substantive meanings, such as nouns, verbs, adjectives, and adverbs, were retained because these lexical categories are useful in identifying semantic topics in social media texts. The processed texts were subsequently converted into a document corpus, and a dictionary of unique terms was constructed to generate the document term matrix for topic modeling. The LDA model was then implemented using Python's Gensim library to estimate the probability distributions of topic word composition and document topic composition. In addition, a time dimension was incorporated to examine the temporal evolution of HPV vaccine topics.

In response to Research Questions 1 and 2, the optimal number of topics (K) was determined by comparing models with different topic numbers using perplexity as the primary evaluation criterion. Following the procedure described by Jiang et al. [11], multiple LDA models with different values of K were estimated, and the corresponding perplexity values were compared to identify the point at which further increases in the number of topics yielded only marginal improvements

in model fit. To ensure model stability and reproducibility, the LDA model was trained using the Gensim library with the number of passes set to 100. Quantitative evaluation was further complemented by qualitative assessment of topic interpretability to ensure that each topic was semantically meaningful and clearly distinguishable. After multiple rounds of parameter tuning and model evaluation, K = 5 was identified as the optimal number of topics because it provided an appropriate balance between model fit, semantic coherence, and interpretability. This topic solution was selected to distinguish interpretable themes without introducing unnecessary model complexity. The resulting labels and distributions summarize the fitted corpus; their stability would require further assessment across alternative initializations and modeling specifications.

Subsequently, the topics generated by the model were evaluated qualitatively using the topic–word and document–topic probability distributions. The topic–word distribution summarized the terms associated with each topic after model estimation. These terms were examined alongside the original posts to assess their contextual meanings and refine the topic labels through manual interpretation. Within each topic, words were ranked in descending order of their estimated probabilities, and approximately ten of the highest-probability terms were selected as representative descriptors. A word with a higher probability therefore appeared earlier in the corresponding list, indicating a stronger association with that topic within the fitted model. The document–topic matrix was then used to characterize the relative prominence of the topics across the corpus. These outputs supported the thematic interpretation reported in Table 2, while examination of representative posts helped distinguish the meaning of individual terms from their isolated dictionary definitions. Topic labels summarize probabilistic patterns in the corpus rather than mutually exclusive categories of individual users or beliefs.

In particular, although some topics contained words that initially appeared irrelevant, this is a known characteristic of LDA, given its reliance on probabilistic co-occurrence patterns. To address this, we implemented a post-modeling refinement procedure. Specifically, the qualitative review considered whether incoherent or overlapping themes could be interpreted, combined, or distinguished more clearly. We also adopted a mixed quantitative and qualitative approach, examining the top-ranked words alongside representative documents for each topic to assess whether "seemingly irrelevant" terms actually reflected hidden associations in social media discourse. In this way, we refined the topic labels and ensured interpretability.

Several high-frequency words initially appeared irrelevant to their assigned topics (e.g., healthy behavior: SMS, need, multiple, website; cervical cancer prevention: men, scam, regular, difference, knowledge). However, further qualitative inspection revealed that these terms were contextually meaningful. For instance, SMS and websites were frequently mentioned in discussions about health promotion campaigns that relied on digital communication channels. Similarly, the categories of "need" and "multiple" reflect users' perceived needs for a variety of health information formats. Within the cervical cancer prevention topic, words such as men indicated public debates on male vaccination and gender roles in HPV prevention, while scam referred to concerns over fraudulent vaccines and misinformation. Terms like regular and knowledge highlighted recurring calls for routine screening and the dissemination of accurate health knowledge.

A content analysis was performed on the most popular 786 posts following data cleaning. The coding process involved two doctoral students. To ensure inter-coder reliability, a random sample of 80 entries (10.2% of the total sample) was selected for training. Based on Altman's strength of agreement, Cohen's kappa values between .61 and .80 indicate good agreement, whereas values between .81 and 1.00 indicate very good agreement [77]. Following the reliability assessment, the remaining sample was coded in full. Two trained coders independently coded all materials according to the coding scheme. After the initial coding, the coders met to review all discrepant cases. Disagreements were discussed until a consensus was reached. The final dataset was based on the consensus reached by the two coders. Each post was coded for the presence (1) or absence (0) of the four main constructs derived from the Extended Parallel Process Model (EPPM): severity, susceptibility, self-efficacy, and response efficacy. Coding decisions were guided by clear operational definitions (see Table 1). Posts had to explicitly mention the construct (e.g., describing cancer seriousness for severity, or providing vaccine accessibility details for self-efficacy) in order to be coded as "present." This ensured a consistent operationalization of each variable.

According to the EPPM, whether people accept or reject fear-inducing information is an important indicator of their engagement with information. In addition to the posts themselves, social media content typically includes system-generated and user-generated social cues, such as views, forwards, comments, and likes. These social cues are commonly used as indicators of observable interaction with information [78]. Prior research suggests that retweeting behavior can be interpreted as a form of social endorsement, as it often reflects users' agreement, trust, and support toward a message or its source [79]. To address Research Question 4, the number of forwards for each post was treated as a continuous dependent variable representing observable user engagement through sharing. Correlation analyses were performed to examine the associations between threat information, efficacy information, and the number of forwards.

Table 1. *Definitions Of Theoretical Variables In The Context Of HPV*

Variable	Definition	Example	Reference
Susceptibility	Information about the likelihood of being infected with HPV that may lead to cervical cancer.	Posts were coded as "present" if they explicitly mentioned individuals' chances of contracting HPV (e.g., statements that most sexually active women will be exposed to HPV at some point in their lives).	[5, 13]
Severity	Information emphasizing the seriousness of HPV-related health consequences, including cervical cancer.	Posts were coded as "present" if they highlighted the harmful consequences of HPV, such as risk of precancerous lesions, organ damage, or cancer development. For example, a message noting that "high-risk HPV types may eventually cause cervical cancer" was coded under severity.	[5, 13]
Self-efficacy	Information about young women's ability to obtain HPV vaccination or access preventive services in China, including practical guidance on vaccination locations, costs, and appointment procedures.	Posts were coded as "present" if they described how women could effectively protect themselves, such as providing vaccine location/cost details or explaining how to arrange an appropriate cervical screening appointment. These are illustrative coding cues about access to preventive services; screening detects infection or cervical abnormalities and does not itself prevent HPV infection.	[5, 13]
Response efficacy	Message features emphasizing the effectiveness of recommended preventive measures, including HPV vaccination.	Posts were coded as "present" if they highlighted the proven effectiveness of HPV vaccination or screening in preventing cervical cancer. For instance, a message noting that "HPV vaccination is the primary approach for cervical cancer prevention" was included in this category.	[5, 13]

4. RESULTS

RQ1 examined the main themes in Sina Weibo discussions about HPV and the HPV vaccine. Using LDA modeling (see Table 2), five key topics emerged: (1) healthy behavior, (2) HPV vaccine, (3) cervical cancer prevention, (4) 9-valent HPV vaccine appointments, and (5) HPV infection. Healthy behavior was the most frequently discussed topic (0.231), followed by cervical cancer prevention (0.209), the HPV vaccine (0.196), 9-valent HPV vaccine appointments (0.184), and HPV infection (0.180), with HPV infection being the least discussed.

Table 2. *Topics Identified In The Corpus*

Topic	Topic intensity	Top terms
Topic 1: Healthy behavior	0.231	"Health", "Protection", "Link", "SMS", "Doctor", "Need", "Boost", "Multiple", "Website", "Risk"
Topic 2: HPV vaccine	0.196	"Vaccine", "Female", "Advice", "Induction", "Attention", "Concern", "Immunization", "Account", "Plan", " Selection"
Topic 3: Cervical Cancer Prevention	0.209	"Cervical Cancer", "Prevention", "Understanding", "Men", "Screening", "Scam", "Importance", "Regular", "Difference", "Knowledge"
Topic 4: 9-valent HPV Vaccine Appointment	0.184	"Nine-valent", "Appointment", "CCTV", "Cold", "Procedure", "Quadrivalent", "First", "Early", "Citizen", "Maternal and Child Health Care"
Topic 5: HPV infection	0.180	"Infection", "Age-appropriate", "Free", "Virus", "Bivalent", "Treatment", "At-risk", "Disease", "Girls", "Support"

Table 2 illustrates these five themes, each closely tied to health-related issues, HPV, and vaccinations. The table lists words with a high probability of association with each topic, along with their respective topic strengths, which reflect the frequency and importance of these terms within the discussions.

RQ2 examined how discussion topics about HPV and the HPV vaccine evolved over time on Sina Weibo. Figure 1 illustrates the intensity changes of the five key themes (health behaviors, HPV vaccine, cervical cancer prevention, 9-valent HPV vaccine uptake, and HPV infection) from 2018 to 2024. In 2018 and 2020, cervical cancer prevention was the most prominent theme, while healthy behavior was the dominant topic in 2019, 2021, and 2023. The prominence of individual topics should be interpreted within the stated 2018–2024 observation window. Overall, from July 2018 to June 2024, conversations on Weibo regarding "health behavior", "cervical cancer prevention", and the "HPV vaccine" fluctuated and saw notable increases at specific times. These spikes indicate moments of heightened public interest. Although these themes varied in intensity, the overall trend shows a consistent rise in discussions of HPV-related topics, with greater frequency and a broader range of issues covered.

Figure 2 presents the reported volume of HPV vaccine discussions from July 2021 to June 2024, providing a complementary perspective on the topic patterns shown in Figure 1. Changes in discussion volume occurred within a policy

environment that increasingly emphasized vaccination access and cervical cancer prevention. In January 2023, the National Health Commission and nine other national bodies issued the Action Plan for Accelerating the Elimination of Cervical Cancer (2023–2030), which encouraged vaccination pilots and strengthened screening and treatment services [80]. The accompanying policy explanation described earlier free-vaccination initiatives in several provinces and cities and encouraged eligible regions to build on those experiences [3]. These developments provide relevant context for interpreting public discussions about prevention, service availability, eligibility, and access. However, the temporal correspondence between public announcements and changes in posting activity does not establish that a particular policy caused an observed increase. The present analysis does not isolate the effects of vaccine prices, commercial announcements, media coverage, or other concurrent events. Accordingly, the peaks in Figure 2 should be interpreted as descriptive indicators of heightened discussion within the sampled corpus. Establishing whether policy or market events explain those changes would require a separately specified event analysis, verified announcement dates, and comparison with the baseline pattern of posting activity. The distinction between relative topic intensity and absolute discussion volume is also important: a topic can become more prominent within the corpus without a corresponding increase in the total number of posts.

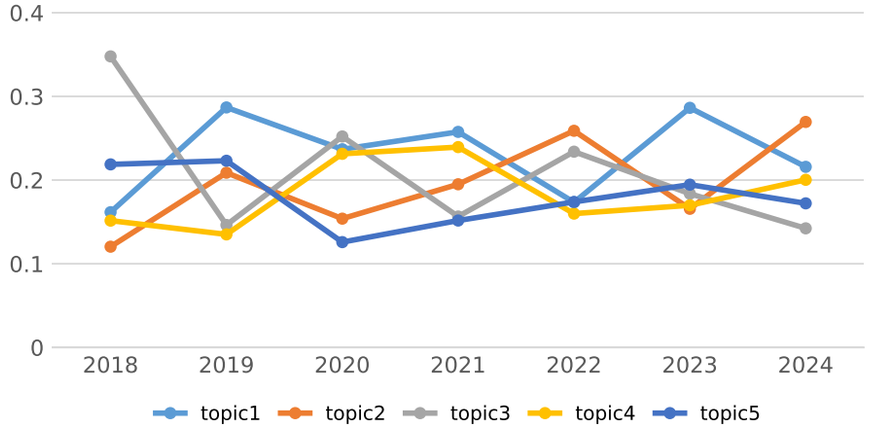


Figure 1. *HPV-Related Topic Intensity Over Time*

RQ3 analyzed the characteristics of HPV threat perceptions and the efficacy of the HPV vaccine in Sina Weibo discussions. Discussions about vaccine efficacy frequently appeared in the context of "HPV vaccine fear appeals". Among these, self-efficacy information (n = 386, 49.11%) was the most commonly mentioned, followed by response efficacy (n = 220, 27.99%). On the other hand, threat information was less prevalent, with threat severity (n = 134, 17.05%) being the least frequently discussed, followed by threat susceptibility (n = 189, 24.05%).

The data in Table 3 show that HPV threat severity was explicitly mentioned in 17.05% of the coded posts (n = 134), whereas it was absent from 82.95% (n = 652). Severity-related information was therefore less prevalent than susceptibility-related information within this selected sample. Susceptibility was present in 24.05% of posts (n = 189) and absent from 75.95% (n = 597). These frequencies describe the explicit message content identified by the coders. They do not indicate the proportion of users who believed themselves to be at risk, because the study did not directly measure users' perceptions or recruit respondents to answer questions about their personal susceptibility.

Regarding response efficacy, 27.99% of the coded posts (n = 220) explicitly mentioned the effectiveness of recommended preventive measures, whereas 72.01% (n = 566) did not contain this component. Self-efficacy information appeared in 49.11% of posts (n = 386) and was absent from 50.89% (n = 400). Absence of a coded component indicates that the post did not explicitly address it; it does not demonstrate that its author doubted the measure, lacked confidence, or rejected vaccination.

Overall, these findings indicate an uneven distribution of threat and efficacy information across the sampled messages. Self-efficacy content appeared in nearly half of the posts, whereas response efficacy appeared in fewer than one-third. Threat-related information was also less frequent than self-efficacy content. Because the four components were coded separately, their percentages are not expected to sum to 100%, and a single post could contain several components. These patterns identify differences in message emphasis rather than evidence of individual psychological deficits. They provide a basis for considering whether public communication adequately explains both HPV-related health consequences and feasible preventive actions, while leaving the effects on audiences' beliefs and behavior to subsequent research.

Spearman correlation analyses (see Table 4) were conducted for RQ4 to examine the associations between threat information (susceptibility and severity), efficacy information (self-efficacy and response efficacy), and user engagement (forwards). Results indicated that severity ($r_s = .25$, $p < .05$) and self-efficacy ($r_s = .22$, $p < .05$) were positively associated

with the number of forwards. Susceptibility and response efficacy were not significantly correlated with forwards. Among the independent variables, susceptibility was moderately correlated with response efficacy (r_s = .44, p < .01) and severity (r_s = .32, p < .01).

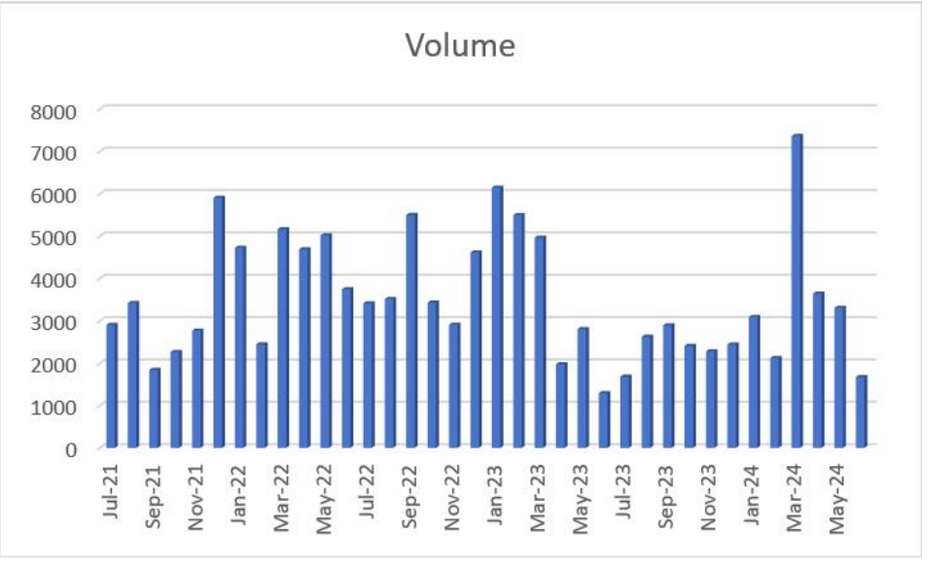


Figure 2. *Discussion Volume Of The HPV Vaccine Topic From July 2021 To June 2024*

Table 3. *HPV Fear-Appeal Message Elements*

	Variables	Present (1)	Absent (0)
Threat	Severity	134(17.05%)	652(82.95%)
	Susceptibility	189(24.05%)	597(75.95%)
Efficacy	Response efficacy	220(27.99%)	566(72.01%)
	Self-efficacy	386(49.11%)	400(50.89%)

Table 4. *Spearman Correlations Among Study Variables (N = 786)*

Variable	Susceptibility	Severity	Self-efficacy	Response efficacy	Forwards
Susceptibility					
Severity	.32**	—			
Self-efficacy	.20*	.24*			
Response efficacy	.44**	.24*	.16		
Forwards	.19	.25*	.22*	.13	

Note: $^{*}p < .05$, $^{**}p < .01$. Off-diagonal coefficients and significance markers reproduce the supplied analysis and require verification against the original statistical output.

5. DISCUSSION

This study analyzed 219,068 discussion posts on the topic of "HPV" from the Sina Weibo platform. A detailed statistical analysis of the themes was conducted using the Latent Dirichlet Allocation (LDA) topic model, combined with manual content analysis. This analysis aimed to uncover the diversity of topics and patterns in information dissemination related to HPV fear and to provide empirical evidence that can support the dissemination of HPV knowledge, enhance public awareness of protection, and optimize public health policies. The LDA analysis first identified the major topics discussed in relation to HPV on Sina Weibo. Among the identified themes, health behavior was the most frequently discussed topic. This finding indicates that HPV-related social media discussions extend beyond disease information itself and include practical and behavioral issues relevant to prevention and vaccination. Social media has become an important channel through which individuals obtain, exchange, and discuss health information. Wu et al. [81], for example, highlighted the role of social media availability and social support in facilitating health information exchange and suggested that online health discussions may provide opportunities for health communication and intervention.

The prominence of health behavior in the present study suggests that social media may provide a useful communication environment for disseminating practical information about HPV prevention and vaccination. For health authorities and health communicators, this finding highlights the value of addressing users' practical information needs, such as vaccination-related knowledge and preventive practices, rather than focusing exclusively on disease risks. Cervical cancer

prevention and HPV vaccination were also prominent themes in the dataset. This finding is consistent with the close relationship between HPV infection, cervical cancer prevention, and HPV vaccination in public health communication. The growing visibility of HPV vaccination in Chinese social media discussions may reflect increasing public attention to vaccination-related information, including vaccine availability, appointment procedures, vaccination experiences, and concerns about potential adverse effects.

Previous studies have similarly identified social media as an important source of health information while noting that users may encounter information of varying levels of credibility. Wong et al. [82] reported concerns and skepticism surrounding HPV vaccination across Asian populations, while Yi et al. [83] examined parents' willingness to vaccinate children aged 9–14 years against HPV, illustrating the relevance of behavioral beliefs and vaccination intentions to prevention efforts. Taken together, these findings suggest that social media provides substantial opportunities for HPV health communication while also creating a need for accessible and evidence-based information. The present study, however, does not directly evaluate the credibility or accuracy of individual posts; therefore, conclusions about information quality should not be inferred from the topic distribution alone.

The content analysis further examined the informational elements present in discussions related to HPV vaccine fear appeals and HPV fear appeals. The results showed that self-efficacy information was the most frequently identified element (n = 386, 49.11%), followed by response efficacy information (n = 220, 27.99%). Threat-related information appeared less frequently, with susceptibility information identified in 189 posts (24.05%) and severity information in 134 posts (17.05%).

The relatively high prevalence of self-efficacy information suggests that HPV-related discussions on Sina Weibo frequently include information concerning what individuals can do in response to HPV-related health concerns. Such information may include practical guidance, personal experiences, or descriptions of actions related to prevention and vaccination. Response efficacy information, although less frequent than self-efficacy information, also appeared in a substantial proportion of posts. These findings indicate that efficacy-related content constitutes an important component of online HPV communication.

In contrast, threat severity and susceptibility were less frequently represented. This pattern may suggest that discussions on Sina Weibo place relatively greater emphasis on what individuals can do than on descriptions of the seriousness or likelihood of HPV-related health risks. However, the present content analysis cannot determine why particular message elements were more or less prevalent, nor can it establish whether the presence of these elements changes individuals' perceived threat, perceived efficacy, emotional responses, vaccination intentions, or actual vaccination behavior.

This study also examined whether different fear appeal components were associated with user engagement on Sina Weibo, operationalized as the number of forwards. The results showed that severity and self-efficacy were positively associated with the number of forwards, whereas susceptibility and response efficacy were not significantly associated with forwarding activity. These findings suggest that different informational elements may have different relationships with users' observable sharing behavior on social media.

The positive association between severity and forwards suggests that posts emphasizing the seriousness or consequences of HPV-related health risks may be more likely to be forwarded. One possible explanation is that information describing serious health consequences may attract greater attention or be perceived as sufficiently important to share with others. Previous research on online health communication has suggested that emotionally salient or high-consequence health information may be associated with greater online engagement [84].

The positive association between self-efficacy and forwards is also noteworthy. Posts containing self-efficacy information may provide practical information concerning what individuals can do in response to HPV-related health concerns. Such actionable information may increase the perceived usefulness of content and, potentially, its likelihood of being shared with others. Chen et al. [13] similarly suggested that efficacy-related information may be relevant to message involvement and information processing in social media environments.

The lack of significant associations between susceptibility, response efficacy, and forwards further indicates that not all components of fear appeal messages have the same relationship with observable sharing behavior. In particular, information emphasizing the seriousness of HPV-related outcomes and information emphasizing individuals' ability to take preventive action showed significant associations with forwarding activity, whereas information concerning perceived susceptibility and the effectiveness of the recommended response did not. This pattern provides an empirical basis for further examining which characteristics of HPV-related health messages are more likely to be disseminated by social media users.

From a theoretical perspective, this study demonstrates the usefulness of the Extended Parallel Process Model (EPPM) as a framework for examining the informational characteristics of health messages in a social media environment. In particular, the distinction between threat-related information and efficacy-related information provides a useful framework for systematically identifying how different components of fear appeal messages are represented in HPV-related social media content. The finding that self-efficacy information was more frequently represented than threat-related information, together with the observed associations between severity, self-efficacy, and forwarding activity, provides empirical evidence for considering EPPM-related message components in the analysis of social media health communication.

The findings also have several practical implications. First, public health authorities and health communicators can use social media as a channel for disseminating clear, evidence-based, and actionable HPV information. The relatively frequent presence of self-efficacy information suggests that practical guidance concerning preventive actions may be an important component of HPV-related communication. When fear-appeal messages are used, communicators should consider presenting information about health risks together with clear information about feasible preventive actions. Such a balanced approach can ensure that audiences are provided with both information about the health consequences of HPV and information about available preventive options. However, experimental research is needed to determine whether particular combinations of threat and efficacy information produce more effective communication outcomes.

Second, the positive association between severity and forwarding activity suggests that information emphasizing the seriousness of HPV-related health consequences may be more widely disseminated on Sina Weibo. Similarly, the positive association between self-efficacy and forwarding activity indicates that actionable information may also be relevant to the dissemination of HPV-related messages. These findings do not demonstrate that such content is more persuasive or more effective in changing vaccination intentions. Nevertheless, they suggest that health communicators may benefit from considering both the informational content and the potential dissemination characteristics of messages when developing social media campaigns.

Finally, concerns surrounding HPV vaccination should be addressed through accessible and evidence-based communication. Previous vaccine-related controversies may contribute to public concerns about vaccine safety, highlighting the importance of transparent communication regarding vaccine safety, effectiveness, eligibility, availability, and vaccination procedures. Public health authorities can strengthen social media communication by providing timely and authoritative information and directing users toward reliable vaccination resources. Rather than assuming that information dissemination alone will increase vaccination willingness, future research should examine whether and under what conditions different communication strategies contribute to changes in knowledge, perceived risk, vaccination intention, and actual vaccination behavior.

6. LIMITATIONS

The content-analysis sample consisted of popular posts and therefore does not represent all posts in the larger corpus or all Weibo users. Selection based on popularity may also affect the observed relationship between message characteristics and forwarding activity. The reported correlations describe associations and cannot establish that threat or efficacy information caused users to share a post. Source characteristics, audience size, posting time, and other unmeasured factors may influence both message content and engagement. In addition, the coding captured explicit textual components rather than users' perceived threat, perceived efficacy, vaccination intentions, or emotional responses. Fear and hope provide a theoretical frame for interpreting communication, but neither emotion was directly measured. Finally, the numerical findings and significance classifications should be interpreted in light of the sampling procedure and the underlying statistical output; replication with transparent sampling criteria, complete reliability statistics, and accessible analysis code would strengthen the evidence.

7. CONCLUSION

This study examined HPV-related discussions on Sina Weibo by combining LDA topic modeling with manual content analysis to identify major discussion themes, characterize the presence of threat and efficacy information, and examine their associations with forwarding activity. The findings show that health behavior, cervical cancer prevention, and HPV vaccination were among the prominent topics in HPV-related social media discussions. These findings indicate that HPV communication on social media encompasses not only information about health risks but also practical information related to prevention and vaccination.

The content analysis further showed that self-efficacy information was the most frequently identified efficacy component, followed by response efficacy, while threat severity and susceptibility were less frequently represented. In addition, severity and self-efficacy were positively associated with the number of forwards, whereas susceptibility and response efficacy were not significantly associated with forwarding activity. These findings suggest that the informational characteristics of HPV-related posts may be associated with their dissemination on social media.

From a practical perspective, the findings highlight the importance of providing balanced and actionable HPV information on social media. Health communicators may consider combining clear information about HPV-related health risks with practical information that helps audiences understand available preventive options. At the same time, the presence of threat information should be considered carefully, particularly when communicating serious health consequences, so that risk information is accompanied by clear and feasible preventive guidance. Social media may therefore provide a useful channel for disseminating evidence-based HPV information and facilitating access to prevention-related knowledge.

Future research should further examine the mechanisms underlying the observed associations between message charac-

teristics and forwarding activity. Experimental and longitudinal studies could investigate whether different combinations of threat and efficacy information affect perceived threat, perceived efficacy, emotional responses, vaccination intentions, and subsequent health behaviors. Future research may also examine other social media characteristics, such as message format, source credibility, audience characteristics, and platform-specific features, to better understand how HPV-related information is disseminated and received in digital environments.

Author Contributions

All authors contributed equally to the study and approved the final manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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Data Availability

The dataset used in this study is available from the corresponding author upon reasonable request.

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