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TikTok and COVID-19 Vaccine Misinformation: New Avenues for Misinformation Spread, Popular Infodemic Topics, and Dangerous Logical Fallacies

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TikTok's microvideo format, audio virality, and algorithmic focus present fundamental shifts and understudied challenges to health communication. This health misinformation study first takes a step toward filling this gap and extends common approaches to TikTok research that rely on a single hashtag. To identify the realistically slippery nature of COVID-19 vaccine misinformation, this study employs algorithm training and snowball sampling across misinformation trails of adjacent hashtags, coded language, audio memes, and user accounts to collect a data set of 100 microvideos across many misinformation-related hashtags. Then, thematic analysis illuminates the dominance of novel misinformation spread through viral music and sounds and other platform features, as well as persistent vaccine misinformation topics, such as side effects, harm to children, and experimental vaccine contents. Finally, rhetorical analysis identifies misleading misinformation arguments, including appeals to the populace and emotion, nirvana, slippery slopes, and false-cause logical fallacies.

Keywords: TikTok, COVID-19 vaccine, health communication, infodemic, health misinformation, misinformation spread, social media, logical fallacies

TikTok has gained explosive popularity in recent years, with 800 million active users spanning 155 countries (Deyan, 2021). More than a billion 5-s to 3-min-long videos are watched per day on the platform (Deyan, 2021). While microvideo social interaction systems have proliferated, our understanding of how health misinformation spreads on these platforms and how to best combat it is still in its burgeoning stages (Bautista, Alonso-López, & Giacomelli, 2021). Most automated misinformation flagging and online health research are predominately and limitingly text-based, and visual and multimodal mediums like TikTok present an ever-growing challenge to misinformation detection (Vizoso, Vaz-Álvarez, & López-García, 2021). Our understanding of the spread of social health information is also rooted in network analysis of users' followers or friends, such as the effects of users' adverse vaccine events on their virtual networks (Bhattacharyya, Vutha, & Bauch, 2019). In this context, TikTok's algorithm-first interactions present a new challenge.

TikTok's rise in popularity coincided with the COVID-19 pandemic. Misinformation and information overload make up no small part of the global struggles with COVID-19, as public health officials try to combat

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both the pandemic and, as the World Health Organization (WHO, 2020) declared in February 2020, the "infodemic." The infodemic, or the overabundance of information with varying degrees of accuracy, makes it difficult for people to find consistent and reliable information (Zarocostas, 2020). Social media platforms must be monitored constantly to detect rumors for public health officials to refute (Zarocostas, 2020).

The infodemic continues to impact COVID-19 vaccine hesitancy and resistance. In April 2022, only 65.6% of the total U.S. population was fully vaccinated, with higher rates of vaccination in the total population over the age of 5 years old at 69.7% (Centers for Disease Control and Prevention [CDC], 2021). The necessity of booster doses and the announcement that the vaccine was safe for children posed additional challenges for vaccine encouragement and promotion.

Antivaccination rhetoric and misinformation have become mainstream and politicalized in the case of COVID-19. Trepidations about the speed of development, approval by government agencies, and broader concerns about government control continue to persist despite messaging efforts by public health officials (Basch, Meleo-Erwin, Fera, Jaime, & Basch, 2021; Liu, Lu, & Lu, 2021).

A more complete understanding of popular COVID-19 vaccine misinformation content on TikTok and how it spreads, evades fact-checking efforts, and persists in a TikTok-specific context could equip public health officials and social interaction designers to combat misleading content. Part 1 of this study pursues these questions by first replicating the sampling methods of a previous study on TikTok videos with the hashtag #covidvaccine (Basch et al., 2021). A collection of videos was sampled from the same hashtag #covidvaccine one year later. Scoping beyond Basch and colleagues' (2021) original sample, an additional 100 videos were sampled from the hashtag #antivaxx. A year later, in the videos sampled for the present study in December 2021, the videos in these two most popular hashtags contained very little misinformation. The low results of the sampling in the first stage of the study led to creative methods in the second stage to identify how and where misinformation was still circulating on the platform.

Second, this study presents a novel exploratory approach to identifying and sampling misinformation-related hashtags. To follow the slippery and evasive nature of misinformation on TikTok, a period of hashtag sampling began, using a toolkit of coded language identification and following misinformation trails from creators to commenters to reusable audio segments, as well as algorithm training. Fifty hashtags related to COVID-19 vaccine misinformation are shared, and tactics identified that help videos in these hashtags evade anti-misinformation detection.

Third, a data set of TikTok videos drawn from these 50 hashtags was analyzed using a digital rhetoric approach. To characterize the features of COVID-19 vaccine misinformation on TikTok, inductive thematic analysis results are shared, including eight identified types of misinformation spread on the platform using new platform-specific features and new and persisting themes within the misinformation content.

Fourth, this study endeavors to add complexity to the characterization of health misinformation on the platform by presenting results from the rhetorical analysis. Rhetorical analysis, specifically fallacy theory, was applied to the videos, and 13 recurring arguments containing specific fallacies or breakdowns in logic leading to false conclusions about the COVID-19 vaccine were found. Together, these findings illustrate an

exploratory sense of the understudied challenges of TikTok-specific health misinformation spread and opportunities for future research.

TikTok: A Health Communication Platform

Some medical professionals have taken TikTok to spread reliable health information. Many of these medical professionals use novel multimodal affordances and easy-access trends on the platform by retooling memes, trends, and humor to create engaging health information content (Stein, Yao, & Aitamurto, 2022). If their content is engaging and becomes popular on the platform's algorithmic ranking feature, the For You Page (FYP), health professionals may see their health content go viral, reaching users who are not actively seeking health information (Ohlheiser, 2020). Healthcare providers have created content related to health topics, including COVID-19 (Eghtesadi & Floreaby, 2020), sexual health (Stein et al., 2022), and gastroenterology (Ohlheiser, 2020). Public health researchers have also urged organizations to move beyond information dissemination by predominately e-mail and phone by creating content on platforms like TikTok where many users are seeking health information (Eghtesadi & Floreaby, 2020).

Users other than medical professionals also share, promote, and exchange health information on the platform. TikTok data have been used in multiple public health studies to assess thematic content in microvideos relating to the pandemic. Basch, Hillyer, and Jaime (2020) studied the effect of quarantine on users and identified a significant theme of anxiety. Mask-wear-prompting TikTok videos (Basch, Fera, Pierce, & Basch, 2021) and COVID-19 testing-related TikTok videos (Basch, Mohlman, Fera, Pellicane, & Basch, 2021) have also been highlighted. COVID-19-related TikTok videos also have the themes of encouragement, personal precaution sharing, and disease information discussion (Li, Guan, Hammond, & Berrey, 2020). Videos on the platform have also been evaluated for information accuracy and misinformation relating to other health topics, such as prostate cancer (Xu et al., 2021), acne (Zheng et al., 2021), and pediatric health (Kriegel, Lazarevic, Athanasian, & Milanaik, 2021).

Misinformation and TikTok

Although misinformation has existed for centuries, its circulation is now amplified as it spreads faster and further (Zarocostas, 2020), thanks to the ease of production and dissemination on social media (Vizoso et al., 2021). Viewing misinformation on social media has been linked to individuals' direct health actions, undermining COVID-19 prevention (Barua, Barua, Aktar, Kabir, & Li, 2020). Exposure to online misinformation has also been shown to have significant impacts on people's thoughts, actions, and memories, taking on additional strength if repeated or if the misinformation aligns with a person's preexisting values and beliefs (Greenspan & Loftus, 2021). TikTok's algorithmic focus and resulting filter bubbles make confirmation bias and information narrowing a particularly high risk on the platform (Li, Zhao, Hussain, Ming, & Wu, 2021).

TikTok's Efforts to Combat Misinformation Spread

TikTok's Community Guidelines prohibit content that is false or misleading, including misinformation related to vaccines (TikTok, 2021). TikTok's Content Advisory Council works with experts across fields, including information science and public health, to preempt ever-evolving misinformation

content and has trained teams working to identify false and misleading content. Users may also report videos containing misinformation. Other efforts include limiting the distribution of videos that have inconclusive fact-checking on the FYP to slow misinformation spread, adding a banner for more COVID-19-related information on all videos with keywords like "vaccine," and redirecting searches associated with antivaccine content to messages by the WHO (TikTok, 2021). These efforts are in line with the WHO's recommendations for fighting an infodemic (Zarocostas, 2020). More research is needed to identify how misinformation spreads despite these efforts by the platform.

Platform Features and Routes for Misinformation Spread

Arguably, the most distinctive aspects of TikTok are its sophisticated algorithmic features and low-cost interaction design (Zhao, 2021). Users do not need to actively choose or search for content; the content constantly streams from the moment the app is opened to the FYP and adapts based on user engagement, such as liking specific videos. Using a hierarchical interest label tree, a user persona and partitioned data buckets recommend personalized content (Zhao, 2021). The platform uses a collaborative filtering algorithm to identify latent interests or content that users have not liked yet but have been liked by other users who engage with similar content (Zhao, 2021). The collaborative filtering algorithm means a user would not need to actively seek vaccine misinformation, but nonetheless may see the content if it is recommended on their FYP. If a user engages with vaccine misinformation content, they will continue to see more and more related content.

TikTok creates opportunities for content to escalate rapidly from any user, leaving the platform vulnerable to misinformation spread. Compared with other social media platforms where users primarily promote profiles, including official health organizations, TikTok's content-focused ranking system furthers the increasing decentralization of information and "truth" (Bautista et al., 2021). The content ranking system allows individual users to easily reach large audiences as quickly and broadly as established accounts, such as public health agencies or government officials, if their content is engaging (Alonso-López, Sidorenko-Bautista, & Giacomelli, 2021). "Engaging" does not need to equate to popular or agreed-upon, so controversial microvideos with misinformation may have many dissenting comments and therefore high engagement, virality, and spread (Alonso-López et al., 2021).

TikTok's algorithm and focus on audio virality create new avenues for post visibility and content connections between posts beyond the hashtag alone. According to Leaver, Highfield, and Abidin (2020), the templatability of reusable audio segments, shared widely through viral trends, is the most groundbreaking feature of the platform. These reusable audio segments can be understood as "audio memes" (Abidin, 2021) and make it easier for users to repurpose a dance or joke using an existing viral sound and create content. Users only need to lip-sync to share a video using a speech audio-meme with misinformation or join an easy-access trend using specific songs and bodily motions to convey their agreement with misinformation or antivaccine sentiment. TikTok also fosters interactive "communication trees" (Medina Serrano, Papakyriakopoulos, & Hegelich, 2020), where users generate branches of responses to existing content by using features like dueting a video side by side, replying to comments, or stitching a video by adding a video response after the original video plays.

Further research is needed to understand (1) where COVID-19 vaccine misinformation appears on the platform, approximated by first straightforward and then coded hashtags, (2) what characteristics, themes, and logical fallacies appear in vaccine misinformation microvideos, and (3) how vaccine misinformation spreads on the platform despite the platform's actions to combat misinformation. These questions are relevant to ongoing research and public health efforts. This study is only a first step toward better understanding misinformation spread on a wildly popular social media ecosystem with key platform differences that necessitate new applications of methods.

Research Questions

RQ1: As a starting point, how much misinformation appears in the top 100 videos in #covidvaccine and has there been a change over time? To expand the search, how much misinformation appears in #antivaxx?

RQ2: What hashtags using coded language are relevant to COVID-19 vaccine misinformation?

RQ3: What characteristics, themes, and misleading logical fallacies appear in top-trending COVID-19 vaccine misinformation microvideos on TikTok?

RQ4: How does COVID-19 vaccine misinformation spread on TikTok, including novel platform features and tactics used to avoid detection?

Methodological Framework

Digital rhetoric, as a theory, method, and practice (Eyman, 2015), offers a methodological backbone for pursuing these questions about digital texts (microvideos) and how they circulate on TikTok. Digital rhetoric, at its simplest, is the "application of rhetorical theory (as analytic method or heuristic for production) to digital texts and performances" (Eyman, 2015, p. 44), as well as an integrated theory that aims to identify the "characteristics, affordances, and constraints" of new types of digital media (Zappen, 2005, p. 321). These underlying principles suggest that methods of rhetorical analysis and analysis of the characteristics of digital texts like TikTok videos are necessary to investigate a complex phenomenon like health misinformation. A digital rhetorical approach to TikTok health misinformation offers opportunities for a richer and more nuanced understanding of how misinformation is communicated in technically or rhetorically complex ways and how it circulates through unexpected avenues of new technical affordances.

The specific concepts within digital rhetorical theory most helpful to this study's questions are circulation, interactivity, multimodality, and fallacy. Circulation, or theorizing how discourse moves through time and space, is an example of a rhetorical theory that requires extension and "revision" for the postprint world (Eyman, 2015). The circulation of discourse, including misinformation, is now a more participatory model (Jenkins, 2014), where users directly circulate misinformation by sharing and reposting, and circulate misinformation via interactivity on social media by liking, remixing, collaboratively creating, commenting on, responding to, and shaping misinformation. TikTok microvideos are also multimodal, with a constant mix of text, images, audio, and videos.

Some misinformation content comes in the form of presenting incorrect information, which may be organized and analyzed by thematic analysis (Braun & Clarke, 2006, p. 81), a useful method in any theoretical framework. Rhetorical analysis is necessary when misinformation comes in the form of arguments where errors in reasoning lead to false conclusions. Fallacy theory, a subset of larger rhetorical theory, has a history reaching all the way back to Aristotle. Fallacies feature in arguments that appear to be true yet have an error in reasoning. Fallacy theory is a useful framework for identifying exactly how these false conclusions are reached by supplying lists of typical types of fallacies. These fallacy types each contain an error in reasoning that follows a specific pattern and can be identified, named, and defined (Copi, Cohen, & Rodych, 2016, p. 107). Irving Copi's (1961) *Introduction to Logic* presented a set of core fallacies drawn from Aristotle and Locke that many consider to be the "standard," traditional fallacies (Hansen, 2020), which have since been updated (Copi et al., 2016). Due to their standard usage in research and pedagogy, Copi and colleagues' (2016) fallacies are used in this study, and each of the nine relevant fallacies is defined in Table 1.

Data Collection

Initial Microvideo Collection and Sparse Analysis

(RQ1) A starting point needed to be determined to begin data collection. Operationalizing the sampling method of a previous study (Basch et al., 2021) had two major benefits. First, the hashtag #covidvaccine was the most logical hashtag, offering a branching-off point for exploratory snowballing methods to track misinformation flows. Second, taking a baseline assessment of the ratio of misinformation to reliable information in the top 100 videos in #covidvaccine illuminated changes over time.

As an additional branching-off point, the top 100 microvideos under #antivaxx were collected. This hashtag was selected because of its clear antivaccine sentiment and high total views (182.1 million). The top 100 microvideos of each hashtag—#covidvaccine and #antivaxx—were collected manually using stable URLs. Sparse content analysis quantified how many videos contained misinformation, reliable information, misinformation debunking, or irrelevancy. Other general characterizations included whether the content was humorous/satirical or not in English. The low results of misinformation in these locations (RQ1) spurred the selection of additional methods to identify how misinformation was circulating (RQ2).

Expanding the Scope: Hashtag Collection

To locate the COVID-19 vaccine misinformation on TikTok, additional methods were needed to expand the scope of the search in RQ2.

Snowball Sampling Users

From the videos collected from #antivaxx and #covidvaccine (N = 200), the users refuting reliable information in the top 10 comments of each video were identified, and their profiles, videos, and liked videos were viewed to collect relevant hashtags. The additional misinformation-related hashtags appearing with #covidvaccine and #antivaxx in the original 200 videos were also collected.

Snowball Sampling Audio

Audio trends used in misinformation videos and videos parodying antivax trends in the preliminary data set, as well as audios used in videos sampled by users, were followed to the respective audio pages. Videos using the audio were then viewed to collect additional hashtags.

Algorithm Training

A new TikTok account was created in Illinois and trained by observing and engaging with videos with antivaccine content until saturation was reached when most of the videos recommended on the account's FYP contained antivaccine information. Training the algorithm included searching for and interacting with the 20 hashtags identified in collection strategies 1 to 3. Videos on the trained FYP were viewed until 30 additional, most relevant hashtags were collected. The saturation point at 50 hashtags was determined when a few new hashtags with high views were identified as more microvideos were viewed.

Microvideo Collection

The hashtag bank (N = 50) was then categorized into four overarching categories: hashtags relating to vaccine availability for children, politicized rhetoric, overt antivaccine, or wellness and conspiracy. The 10 hashtags with the highest number of views at the time of data collection, with at least one hashtag from each category for relative representativeness, were then sampled. The top-trending 10 relevant videos for each hashtag were then manually collected to form the data set for 100 videos. Only videos relevant to the vaccine in English were selected. Operationally, misinformation was defined here as information that did not align with the most recent guidelines and information shared with the public by the WHO and the CDC on their respective websites at the time of data collection.

Data Analysis

Content Analysis

Content analysis has been employed in several existing studies to characterize TikTok videos relating to COVID-19 (Basch et al., 2020; Basch, Fera, et al., 2021; Basch, Mohlman, et al., 2021; Li et al., 2020). Based on the precedent of these studies, this coding scheme included engagement statistics: number of likes, comments, shares, and video length. Codes for *modes* used included text, speech, music, images, and acting, as in Li and colleagues (2020), as well as dance and humor, as in Basch and colleagues (2020).

Thematic Analysis

Due to the wildly unpredictable nature of health misinformation, this study took an inductive approach to identifying the misinformation spread types (RQ4) and themes (RQ3), rather than using CDC or WHO fact sheets as the basis for the coding scheme, as in Basch and colleagues (2020, 2021). While comparisons were made to the themes identified in the existing studies in the discussion, they were not used to deductively guide the coding schema. Instead, thematic analysis was used to identify prevalent new and developing misinformation topics. Thematic analysis is an actively undertaken qualitative method for "identifying, analyzing, and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 79).

To investigate how misinformation spreads and circulates on the platform (RQ4), each video was assigned a *spread type*. Because they do not exist in the literature, a process of thematic analysis, as described by Braun and Clarke (2006), was used to define spread types after a period of initial review of the data set, reflexive journaling, and generation of an initial list of the observed ways misinformation was being shared and through what platform features. The codes were then grouped and consolidated into the final eight spread types, defined in Table 4 in Results, and applied to the data set systematically.

The content of the videos was analyzed using two methods. First, thematic analysis was applied as in the spread types, with the additional step of visual thematic mapping to review the themes for representativeness of the data set, coherency, and distinctiveness of each theme. The final eight themes, listed in the Results section, were then applied to the data set.

Rhetorical Analysis

The videos were also analyzed using traditional rhetorical analysis, as standard in digital rhetoric (Eyman, 2015; Zappen, 2005) and as prominently illustrated by Losh (2009), who argued that classical rhetoric, with its focus on public oration, was strongly relevant to digital texts that circulate speech. Identifying fallacies is a popular form of rhetorical analysis, especially for political speech, and has recently been applied to political debates on social media (Hidayat et al., 2020). Operationally, the logical fallacies applied for analysis are Irving Copi's fallacy types, originally introduced in 1961, which are considered a standard list of core fallacies (Copi et al., 2016). The nine fallacy types identified in the TikTok videos are defined in Table 1, as defined by Copi and colleagues (2016).

Table 1. Relevant Fallacy Types and Their Definitions.

Fallacy types	Fallacy definitions, from Copi and colleagues (2016)
Appeal to emotion	"when the support offered for some conclusion is emotions–fear, envy, pity, or the like–of the listeners" (p. 124).
Appeal to the populace	"when the support offered for some conclusion is an inappropriate appeal to a multitude" (p. 124).
Begging the question (circular argument)	when "the conclusion of an argument is stated or assumed in any one of the premises" (p. 142).
Hasty generalization	when "a principle that is true of a particular case is applied, carelessly or deliberately, to the great run of cases" (p. 137).
False cause	"accepting as the cause of an event what is not really its cause" (p. 137).
Missing the point	"when one refutes, not the thesis one's interlocutor is advancing, but some different thesis that one mistakenly imputes to him or her" (p. 124).
Red herring	"when some distraction is used to mislead and confuse" (p. 124).
Slippery slope	when "change is asserted to lead inevitably to further changes (usually undesirable) in the same direction" (p. 135).
Straw man	"deliberately misrepresenting an opponent's position," (p. 124), including comparing their case to an imagined perfect option (nirvana fallacy; p. 117).

To ensure the validity of this exploratory analysis approach, the author sought feedback on coding from colleagues at each step of the process, including feedback generated while presenting in a guest lecture and an invited talk. All content used in this study is publicly available.

Results

Revisiting Misinformation Hashtags on TikTok

Basch and colleagues (2021) analyzed the information and misinformation available on TikTok about the COVID-19 vaccine, using the top 100 #covidvaccine videos from December 2020 (published in 2021). In total, they found a division in the data set, with 36 videos encouraging vaccinations and 38 discouraging vaccinations. Even videos that encouraged vaccination sometimes contained misinformation that falsely claimed the vaccine was available for public uptake (7), which was not at the time (Basch et al., 2021).

The change over time has been dramatic since Basch and colleagues' (2021) study was conducted. The top 100 videos in the hashtag #covidvaccine collected in December 2021 contain far fewer videos with misinformation. Of the 100 videos collected in 2021, most contained reliable information (78), with only 13 videos containing misinformation. In both studies, the current study and Basch and colleagues' (2021) humorous parodies of adverse reactions were very prevalent: 26 (Basch et al., 2021) and 13 (current study), making up the majority of misinformation. In contrast, in the top 100 #antivaxx videos, only six videos actually contained misinformation. The majority of videos (67) mocked antivaxxers by parodying their trends on TikTok or adding twist endings. These satirical videos may prove difficult for automated systems to appropriately classify. Twenty-one videos featured misinformation debunking, and four videos were unrelated. A straightforward approach to collecting videos from two hashtags, especially very popular and well-monitored ones, will probably no longer work to identify a significant amount of COVID-19 vaccine misinformation on TikTok, based on these preliminary findings.

Misinformation Prevalence and Characteristics

To find where misinformation was now thriving on the platform, relevant hashtag identification sampling was conducted until 50 COVID-19 vaccine misinformation hashtags were identified, as shown in Table 2.

Table 2. Total Hashtags Collected and Categorized by Broad Theme

Vaccines for children	*Political rhetoric: freedom and choice*	*Overtly antivaccine*	*Wellness and conspiracy*
#StoptheJabon-kids	#letsgobrandon	#Stopthejab	#HealYourself
#Saveourkids	#pureblood	#Stopthemandates	#ImmunityBooster
#Saveourchildren	#donotcomply	#endmandates	#NaturalCovidRemedy
#Savethechildren	#Enoughisenough	#unvaxxed	#COVIDDetox
#Nojabsforkids	#Mychoice	#Jabkills	
#Saveourkidsfrom-government	#Mybodymychoice	#F**kavax	#Chinaflu
	#Freedomof Choice	#F**thejab	#planneddemic
	#StandforFreedom	#VaxisWhack	#Vaccine-

#leavethekids-alone	#TakeAmericaBack	#covidvaccinenotsafe	conspiracy
#Antivaxx-momma	#VaccinePassport	#NoVax	#Wakeup
#antivaxmom	#MedicalFreedom	#NoJab	#wakeup-america
	#PersonalChoice	#antivaxxersolidarity	#WakeupUSA
	#JustSayNo	#Vaxxkills	
		#novaccineforcovid19	
		#vaccinesideeffects	

Of this 50-hashtag bank, the 10 hashtags with the most views at the time of data collection were selected and their top-trending 10 videos were collected for a total of 100 videos (Table 3). These 100 videos form the basis for the following analyses. The total 100 microvideos in the data set together garnered a substantial 18,944,844 likes, 2,341,773 shares, and 320,013 comments. Videos ranged in length from 6 seconds to 3 minutes, although videos longer than a minute were outliers. Average likes and views per video were variable, generally mirroring the views' variation at the hashtag level in Table 3. In the data set, videos contained text (53), music (37), speech (45), audio-visual or film content (25), lip-syncing (13), visual aids like images (12), dance, motions or acting (10), and protest signs (6).

Table 3. Sampled Hashtags and Their Total Number of Views.

Hashtag	*Number of Views*	*Hashtag*	*Number of Views*
#covidvaccine	2.6 Billion	#donotcomply	34 Million
#stopthevaccines	703 Million	#nojabforme	30.1 Million
#medicalfreedom	93.8 Million	#leavethekidsalone	3.3 Million
#vaccinesideeffect	80.2 Million	#stopthejab	2.4 Million
#stopthemandate	71.9 Million	#planneddemic	1.4 Million

Evasion Tactics

Misinformation was no longer appearing as prominently as in #covidvaccine and #antivaxx, which were popular and well monitored. Instead, some antivaccine users in the Part 2 data set adopted detection-evading tactics. To avoid the removal of their content, antivaccine creators used acronyms, emojis like the shot emoji, and intentional misspellings, such as "get the v***ne" (A. Rose, personal communication, November 11, 2021) or other variations like "v@**innated" (H. Rae, personal communication, August 28, 2021). Antivaccine creators also used coded language like #chinaflu and new terms, such as the "jab" instead of vaccine, "pureblood" as a stand-in for nonvaccinated status, echoing both *Harry Potter* (Rowling, 1999) and a long history of eugenics and purity wellness detoxes, and political phrases like "let's go Brandon" (A. Rose, personal communication, November 11, 2021). Vaccine misinformation creators also co-opt existing language and hashtags from other campaigns, such as #mybodymychoice (Figure 1).

Figure 1. TikToks using misspellings, coded language, and appropriated hashtags (A. Rose, personal communication, November 11, 2021; C. Jas, personal communication, October 5, 2021).

Misinformation Spread and Features

In addition to evasive tactics, it was important to investigate how misinformation circulated on the platform. Eight spread types were identified in the Part 2 data set and defined, as shown in Table 4.

Table 4. Misinformation Spread Types on TikTok: Definitions and Examples.

Misinformation Spread Types on TikTok	Definitions and Examples
Stitch	spread using TikTok's stitch function, such as creating a video responding to another user's misinformation-related video prompt and "stitching" the video the play after the original
Duet	spread using TikTok's duet function, such as reacting to a video containing misinformation by "dueting" it side by side and agreeing using facial expressions
Reply to comments	replying in video format to a TikTok comment, for example, either agreeing or disagreeing using misinformation
Audio trend—Music	spreading misinformation by reutilizing a TikTok audio of music, for example, to perform a COVID-19 vaccine-resistant trend
Audio trend—Speech	spreading misinformation by reutilizing a TikTok audio of speech, for example, lip-synching another creator's speech sharing misinformation

Other social media	spreading misinformation from a different social media platform, for example, sharing a tweet onscreen as a TikTok video
News	spreading clips from traditional new sources in a TikTok video, for example, an out-of-context snippet of a press release
Talk shows	spreading snippets containing misinformation from conservative talk shows, for example, as new audio to a TikTok video
Original	Independently sharing new misinformation, for example, by creating a skit

TikTok's novel audio and interaction features featured prominently in the types of misinformation spread in the data set (Figure 2). Some videos contained more than one spread type, such as playing an antivaccine audio trend over visual material spread from news sources, conservative talk media, or other social media. Audio memes were the most common spread type, even when separated into music (37) versus speech and sound (13). Directly copying snippets from news sources, including press conferences by politicians and public health officials, appeared with surprisingly high frequency (18). Only 16 videos contained original content, such as orally sharing others' experiences (9) or creating original skits (7). Interaction capabilities in the app called branching "communication trees" by Medina Serrano and colleagues (2020) allowed misinformation to spread directly within the app by duets (10), stitched videos (7), and replies to comments (4). Cross-platform spread also appeared on Facebook (2), Twitter (3), and Instagram (1). Additional videos may contain misinformation from other social media platforms, but only these six videos illustrated exact screenshots identifiable as other platforms. Most misinformation in the data set comes from another source and is not independently created.

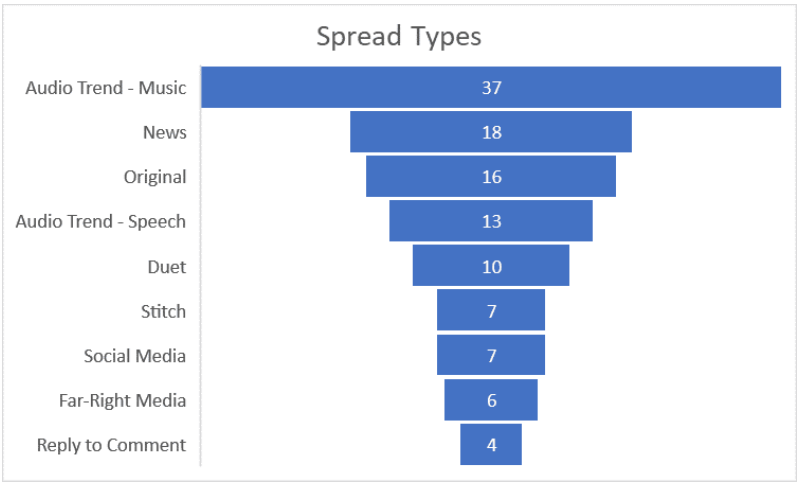

Figure 2. Visualization comparing misinformation spread type frequency.

Many reusable audio segments were identified in the vaccine misinformation videos (Table 5). Some videos followed trends that were used in other contexts, such as the dance trend to Young MA's "Hello Baby" (Marrero, Ryles, & Coleman, 2021). Other videos appealed to emotions by using music like "epic emotional" or "violin." Other music trends included lamenting the COVID-19 vaccine situation by singing along to Caitlynne Curtis's "God We Need You Now" (Harness, 2021), a parody song "Fauchi Ouchie" (Mundeezy, 2021), music by Nicki Minaj (a prominent antivaccine musician; Minaj, Hylton, & Johnson, 2010), and songs that relate to values of patriotism, strength, and protest, such as Coffey Anderson and Drew Jacobs's (2022) "Mr. Red White and Blue," Nu Breed's "Welcome to My House" (Howard & Breed, 2020), Twisted Sister's "We're Not Gonna Take It" (Snider, 1984), and The Chicks' "Not Ready to Make Nice" (Maines, Maguire, Robison, & Wilson, 2006).

Table 5. Misinformation TikToks' Audio Trend Titles.

General & Emotional Audio Trends	Speech Trends	Music Trends
Hello Baby (Marrero et al., 2021)	How Strong I am	God We Need You Now (Harness, 2021)
Get Into It (Dlamini, Starace, & Cheung, 2022)	Everyday it's getting closer	Hunger Games (Jacobson & Kilik, 2012)
Slowed (Bertke, 2015)	I Choose Violence	Mr. Red White and Blue (Anderson, 2022)
Turnt Up (Brown, 2017)	I Ain't doing that sh*t	ACDC-Beegees (Gibb, Gibb, & Gibb, 1977; Johnson, Young, & Young, 1980)
Epic Music	I'mma deal with it	Fauci Ouchie (Mundeezy, 2021)
Epic Emotional	An Alliance, With Me (Silverman & Daniels, 2005)	This is My Country; This is Who-I Am (Howard & Breed, 2020)
Violin	Mind your d*mn business	Super Bass (Minaj et al., 2010)
	Transformers (Bonaventura, DeSanto, Murphy, & Bryce, 2007)	Superman (I'm not that Naïve; Ondrasik, 2001)
	Trump (fight fight fight)	We're Not Gonna Take It—Twisted Sister (Snider, 1984)
	KMFOS (Wake up)	How Do You Like Me Now?! (Keith & Cannon, 1999)
	No Mask No Vax	Danger Zone (Whitlock, 1986)
	Not good for you	Unbelievable (Dench, 1990)
	Rise Up	Not Ready to Make Nice—The Chicks (Maines et al., 2006)
		Run Fast for Your Children (Welch & Summers, 2009)

Less immediately clear from the audio title, the line "I'm not that naïve" in Five for Fighting's "Superman" (Ondrasik, 2001) was used to relate vaccine supporters to naivete, and the line "run for your children" from Florence + The Machine's "Dog Days are Over" (Welch & Summers, 2009) were used in a trend where parents picked up their children in the video and ran to protect their children from vaccination.

Audio trends containing speech allowed misinformation to spread more directly. Examples include creators lip-synching other creators' language, such as the vaccine being "not good for you," or lip-synching

calls to find other vaccine protestors out there through quotes from movies like *Transformers* (Bonaventura et al., 2007) or the 3-finger salute from *The Hunger Games* (Jacobson & Kilik, 2012) as illustrated in Figure 3. Other quotes from these audio trends included calls to wake or rise up, to "form an alliance" with a quote from the TV show *The Office* (Silverman & Daniels, 2005), and to "fight, fight, fight" in a quote from Donald Trump (Smith, 2021). All sound titles are listed in Table 5.

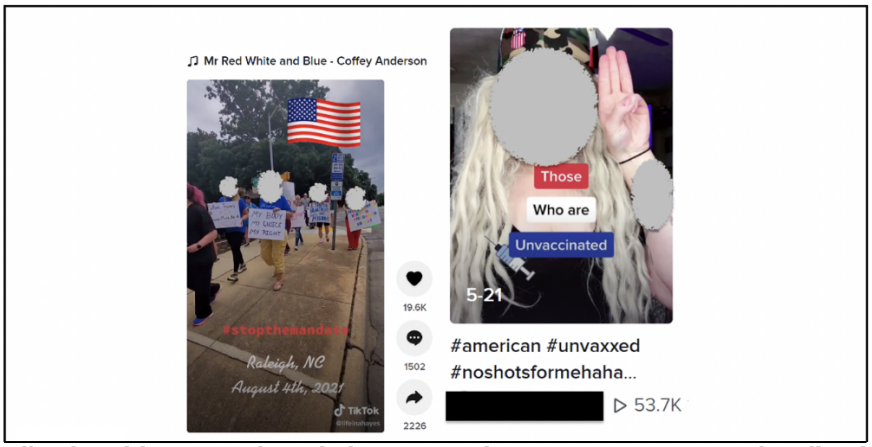

Figure 3. TikToks with co-opted symbols, protest signs, text, gestures, and audios (A. Hayes, personal communication, August 4, 2021; B. Change, personal communication, August 26, 2021).

Two rounds of thematic analysis distilled eight misinformation topics (Figure 4). The least frequent topics included encouragement to seek herbal alternatives to the vaccine (6) and videos suggesting that the pandemic was planned (7). Videos with topics about vaccine contents (9), videos insisting that the vaccine is experimental and was developed too quickly to be proven (12), and videos sharing that COVID-19 is not dangerous (13) appeared more frequently. Top topics included that the vaccine is harmful to children and pregnant women (15), that there is a government conspiracy (17), and misinformation relating to the short- or long-term effects of the vaccine (17).

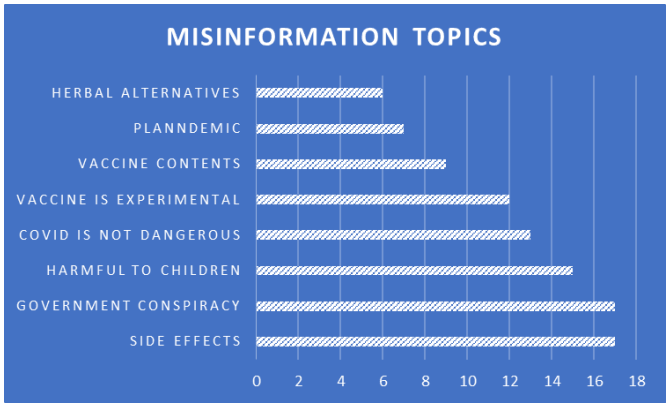

Figure 4. Visualization comparing the frequency of misinformation topics.

Logical Fallacies in Misinformation on TikTok

Often, COVID-19 vaccine misinformation appeared in the form of an argument with an incorrect conclusion caused by an error in reasoning. Rhetorical analysis applying Irving Copi's standard list of logical fallacies (defined in Table 1) to each video identified nine types of fallacies in the data set. Some fallacy types appeared more than once in the 13 identified recurring arguments containing logical fallacies. Each of these reoccurring arguments is summarized in Table 6, along with the fallacy type identified in that argument and a count of how often that argument appeared in the data set. Some videos contained multiple misinformation topics or logical fallacies.

Table 6. Reoccurring Arguments With Logical Fallacies and Their Fallacy Types.

Reoccurring Argument Containing a Logical Fallacy	Fallacy Type	Count
Antivaccination is logically associated with other conservative values	Appeal to the populace	14
Vaccine risks are greater than COVID-19 risks or vaccine benefits	Hasty generalization	11
There is a large and growing number of antivaccine supporters	Appeal to the populace	10
Individuals fired for failing to comply with mandates are victims	Appeal to emotion	9
If the vaccine does not 100% prevent the spread, it is not worthwhile	Nirvana fallacy	9
Vaccination mandates will lead to increasing government control and medical discrimination	Slippery slope	9
Vaccination is the same as abortion or mail-in voting	Red herring	9
There are only two choices, vaccination or freedom	Appeal to populace	8
If boosters are necessary, then the vaccine is not worthwhile	Nirvana fallacy	4
The more the public health officials promote the vaccine, the more proof there is that it is not effective	Circular argument	3
Because research changes over time, the current science is invalid	Hasty generalization	3
Vaccination causes increased cases	False cause	2
Because the vaccine has individual benefits, the choice not to vaccinate has no effect on others	Missing the point	2

Discussion

Methodology

The findings in the first stage of the study imply that a straightforward sampling approach, such as collecting videos from two hashtags (a common approach to data collection from TikTok), will no longer be effective in identifying a significant amount of COVID-19 vaccine misinformation when these hashtags are popular and well monitored.

The hashtag and video sampling methods in the second stage, however, did locate high amounts of misinformation and may be useful to other misinformation researchers. Content analysis of the data set illustrated the popularity and high-view counts of this misinformation. The results suggest that the highly

multimodal nature of these digital texts, in which meaning is produced by multiple simultaneous modes, may not be easily captured without qualitative methods.

Evasion Tactics

Multiple misinformation-flagging tactics were identified, including acronyms, emojis, misspellings, new terms, and new coded and co-opted language. These misinformation-sharing tactics have also been observed on other platforms, including disguised language on YouTube (Machado, Shimizu, & Gitahy, 2021), lexical variations on Instagram (Moran, Grasso, & Koltai, 2022), and dog whistling has a long history, recently highlighted in digital spaces in far-right contexts by Åkerlund (2022). Their presence on TikTok merits additional research for effective misinformation spread detection.

Misinformation Spread

Misinformation is spreading in feature-specific ways on TikTok, which merits future research. The majority of misinformation in the data set came from another source and was not independently created. Among spreads using stitch, duet, and reply to comment functions, audio memes were the most common spread type. This result reflects wider research that situates audio memes as the driving force of the platform (Abidin, 2021). Further investigation into specific audio memes emphasized the diversity of audio trends for antivaccine sentiment and how trends can be co-opted. The prevalence of audio memes for misinformation spread suggests that this form of spread should be the focus of future research on misinformation spread through microvideo mediums.

Misinformation Topics

Many of the misinformation topics found in the data set have been issues throughout the pandemic. Claims that COVID-19 is not dangerous, is a fear-mongering scam, or is a hoax have been critically addressed in earlier literature (Basch et al., 2021; Liu et al., 2021). Misinformation claiming that the vaccine has not been tested, proven, approved by authorities, is experimental, uses people as lab rats, or was developed too quickly to trust all appeared in a study using TikTok data before the vaccine was even available (Basch et al., 2021).

The misinformation topic of government conspiracy, where the government withholding important information, does not require its own people to vaccinate, inflate death counts, or plan the pandemic, has also been an issue throughout the pandemic (Basch et al., 2021; Liu et al., 2021). These government-focused conspiracy theories appeared in antivaccination rhetoric about other vaccines before the pandemic (Germani & Biller-Andorno, 2021). Conspiracy rhetoric also featured in the microvideos in this data set with misinformation about vaccine contents, with users claiming the vaccine contains aborted fetus body parts, code to modify genetic material, magnets, nanosized razor blades, microchips, mind control, tracking devices, or bioweapons.

Misinformation about whether the vaccine is harmful to children and pregnant women or is ineffective in general also appears in previous literature on COVID-19 vaccine hesitancy (Liu et al., 2021).

In some videos in the data set, ineffectiveness misinformation was specifically framed around the idea that herbs, ivermectin, alternative remedies, or natural immunity from having COVID-19 should be sought over the vaccine.

Misinformation about adverse reactions, side effects, and long-term effects continues to be the most frequent topic on TikTok. Misinformation identified in this study included claims that the vaccine's immediate and long-term side effects are dangerous to most people, including risks of mental impairment, becoming a "zombie," physical impairment, bodily deformities, harm to reproductive organs, and that the vaccine kills both children and adults. The continued appearance of misinformation about side effects in meme, skit, and parody forms, while humorous, could still reflect and encourage antivaccine sentiment.

Logical Fallacies

The ability to critically identify logical fallacies is an increasingly important part of effective digital literacy (Hidayat et al., 2020). Logical fallacies have long been used in political rhetoric, so their appearance in increasingly politicalized vaccine misinformation is not particularly surprising (Hidayat et al., 2020). Unfortunately, fallacies are more difficult to refute than outright misinformation; for example, claims that the vaccine contains microchips. Identifying recurring logical fallacies in TikTok videos is the first step in combatting these complicated claims. The videos contained the following fallacies, as listed in Table 6.

Appeals to the Populace

The continued politicization of COVID-19 public health policies in the United States, such as masking, mandates, and vaccination, has had detrimental effects on public health goals. One logical fallacy appearing in many videos is that antivaccination is associated with patriotic feelings and other conservative values of the populace. Creators followed trends in which they listed many values, such as modesty, Christianity, backing police officers, transphobia, or support for the second amendment, and then listed nonvaccination status, despite these values having no necessary connection. Videos also overstated the number of nonvaccinated individuals and showed crowds, protests, and long trains of stitches of multiple creators to connect the antivaccine message with appealing to the majority or persuading others to jump on the bandwagon. Finally, videos also appealed to users' emotions about patriotism by presenting a false dilemma of only two choices: vaccination or all positives associated with freedom, such as courage, strength, and the protection of others' freedom.

Appeals to Emotion and Slippery Slopes

Many videos appealed to emotion using emotional music or users visibly crying in their microvideos to illustrate victimization when facing penalties after failing to follow vaccination requirements. These appeals change the focus from the risks these choices pose to others to the emotions creators experience when facing penalties from their places of work. Emotional appeals were also common in antivaccination rhetoric before COVID-19 (Germani & Biller-Andorno, 2021).

Slippery slope fallacies, or videos where creators argued vaccination mandates would necessarily lead to increasingly perilous future events, fell into two fear-inducing cases. Some videos argued that complying with the mandates would lead to increasing government control, such as the government taking all parental rights, gun rights, or people's bodily autonomy, to the extent of forced procedures like sterilization or organ donation. Other videos argued that vaccine mandates would lead to a slippery slope of medical discrimination, where doctors could refuse to treat patients for less and less feasible reasons, such as patients' choice to eat fast food.

Red Herring and Missing the Point

Other creators argued that vaccination is the same as abortion or mail-in voting, which is an unrelated distraction (red herring). Creators also reached irrelevant conclusions by missing the point, such as assuming that, because the vaccine has individual benefits, the choice to vaccinate *only* has individual effects and no effects on others.

Hasty Generalizations and Nirvana Fallacies

Creators using these fallacies shared generalizations based on only a few cases while ignoring or lacking an understanding of other evidence and contexts. For example, creators argued that vaccine risks are greater than COVID-19 risks by focusing on and generalizing from a small number of unlikely and severe vaccine reactions like blood clots. Likewise, the claim that because research changes over time, the current science is invalid generalizes that all science is untrue because previous recommendations have proven "untrue" (no longer recommended) and ignores context such as additional testing of the vaccine before its approval for children.

Nirvana fallacies also disregard context by arguing that, because something is not perfect, it is completely invalid or unhelpful. Creators argued that because the vaccine does not 100% prevent the spread of the virus (a misunderstanding of the goals of the vaccine, as well), it is completely useless. Similarly, creators argued that because boosters are necessary, the entire vaccine is ineffective and not worthwhile. These fallacies ignore the forest to focus on specific trees or a solution's imperfections.

Circular Argument and False Cause

Creators also incorrectly described the relationship between events. For example, the causal fallacy appeared in claims that, because cases increased in areas following vaccination, the vaccine must have increased the cases. Mistaking the correlation for causation, in this case, ignores how areas with high vaccinations have simultaneously removed many social distancing measures, leading to increases in cases. Relationship fallacies also appeared in videos with circular arguments, where the premise and conclusion were the same and were taken as proof. For example, some creators have argued that the more public health officials claim that the vaccine is effective, the more proof there is that it is ineffective. This is a particularly dangerous fallacy that could render all public health communications targeting nonvaccinated people ineffective.

Practical Implications

This study has sought to supply a basic set of tools to be built upon by other researchers within information science, communication, and public health: playful methods of hashtag identification, a list of COVID-19 vaccine misinformation-relevant hashtags (Table 2), a set of rudimentary types of TikTok-specific misinformation spread and definitions (Table 4), relevant audio titles for exploration (Table 5), and lists of evasion tactics, misinformation themes, and logical fallacies (Table 6) for investigation by future research.

Limitations and Future Work

This study has many limitations. It is explorative, with a small total of 300 video sample sizes that are American- and English-language focused. There is also ambiguity around the ranking of videos that appear on a searched hashtag landing page, which may be impacted by factors, such as the location of the researcher. Future work could investigate the patterns found here and compare these results across a more fully representative sample of videos. There are also many reasons for vaccine hesitancy, such as medical racism (Liu et al., 2021), which is a major factor that does not appear in this data set. Future work is needed to shift the vaccination conversation among both researchers and laypeople from claims that antivaccination supporters are all unintelligent or unreasonable, which does not truly reflect the complexity of these logical fallacies or valid reasons for distrust in medical establishments. More research is needed to understand what rebuttals are successful against these logical fallacies.

Misinformation trends are also constantly changing at a rapid pace, especially on a platform like TikTok, requiring continuous research into better ways to quickly identify misinformation and the spread of misinformation. Future research could also explore other phenomena explicitly identified here, such as detection-evading tactics on TikTok, the roles that humor, music, and lip-synching play in health misinformation sharing, and how platform affordances shape the format and content of future health misinformation.

Conclusions

- Misinformation spreads in complicated and difficult-to-track ways on microvideo platforms.
- TikTok's novel reusable audio and interaction features create new avenues for misinformation spread.
- TikTok users who oppose the COVID-19 vaccine use intentionally coded language, misspelled words, and alternate hashtags to evade antimisinformation efforts.
- Misinformation topics featured in previous COVID-19 vaccine hesitancy literature, such as parodies of vaccine side effects, concerns about vaccine production and approval, conspiracies about governments and vaccine contents, and claims that COVID-19 is not dangerous, are still prevalent despite public health efforts.
- Misinformation about the COVID-19 vaccine and children became more frequent following the vaccine's clearance for children over the age of 5.
- COVID-19 vaccine misinformation often appears in the form of logical fallacies, where some information may be true but misleads to false conclusions.
- Logical fallacies were as frequent as misinformation topics, suggesting that they may be an important avenue for future health misinformation research.

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