Fingerprints of Conspiracy Theories: Identifying Signature Information Sources of a Misleading Narrative and Their Roles in Shaping Message Content and Dissemination

Soojong Kim, Kwanho Kim, and Haoning Xue

Abstract. This study investigates the role of information sources in the propagation and reception of misleading narratives on social media, focusing on the case of the Chemtrail conspiracy theory—a false claim that the trails in the sky behind airplanes are chemicals deliberately spread for sinister reasons. We collected data from Facebook Pages and Groups discussing the conspiracy theory. We specifically focused on identifying and analyzing "signature" information sources, which are repeatedly used by online communities engaged in the discussion of a misleading narrative but are not widely used by other communities. The findings indicate that messages referencing signature sources contain more death-, illness-, risk-, and health-related words, convey more negativity, and elicit more negative reactions from users, compared with those without signature sources. The insights from this study could contribute to the development of effective strategies to monitor and counter the spread of misleading narratives in digital spaces.

1 Introduction

The growing interconnectedness of the World Wide Web and the expansion of social media platforms have given rise to the information ecosystem approach, a new framework for studying the dynamics of information flow (Allen et al. 2020; González-Bailón et al. 2023; Munger and Phillips 2022; Starbird 2017; Watts, Rothschild, and Mobius 2021). This approach examines how information circulates within an ecosystem that comprises various elements such as information sources, dissemination channels, audiences, and infrastructures facilitating interactions among these components.

The information ecosystem approach is valuable for investigating misinformation, disinformation, and extremism, and the complex networks fostering the spread of such content (Hosseinmardi et al. 2021; Kim and Kim 2023; Miani, Hills, and Bangerter 2022). Examining information sources used by actors spreading disinformation, in particular, has been shown to be an effective method for understanding these phenomena (Grinberg

10.54501/jots.v2i2.152

et al. 2019; Guess, Nagler, and Tucker 2019; Lasser et al. 2022). By analyzing how disinformation evolves and persists within the ecosystem, strategies can also be developed to counteract its propagation and mitigate its impact.

The present research aims to investigate the information ecosystem of misleading narratives, a pervasive and influential form of disinformation characterized by cohesive stories built from interconnected false or misleading elements, such as conspiracy theories and propaganda. The objective of this study is to identify and examine distinctive sources of information that are repeatedly used by online communities engaged in the discussion of a misleading narrative but are not widely used by other communities. The current research refers to these information sources as "signature sources" of a misleading narrative. By discovering characteristic patterns of information flows and revealing "fingerprints" of a misleading narrative, the investigation of signature sources is expected to inform preventive and proactive strategies to counteract and curb the spread of disinformation. Furthermore, we explore how these distinctive sources contribute to the formation and propagation of the narrative on social media. We compare these sources with legitimate and credible information sources, to highlight their roles in shaping and spreading the narrative.

The current research examined Facebook communities involved in discussions about conspiracy theories, focusing on the case of the Chemtrail conspiracy theory—a false claim that the trails in the sky behind airplanes are chemicals deliberately spread for sinister reasons. We investigated the role of signature sources in these communities and explored how the use of these sources influences the characteristics of social media posts and their engagement outcomes.

The findings indicate that within these online communities, signature sources are used more frequently than reliable sources, such as government or legitimate news sources. The study also reveals that messages referencing these sources contain higher proportions of death-, illness-, risk-, and health-related words, exhibit a more negative tone, and attract more negative reactions from users. These results highlight the significant role of this specific group of information sources in shaping the content, tone, and reactions to messages within online communities engaged in circulating misleading narratives.

1.1 The Information ecosystem of misleading narratives

The role of information sources is particularly crucial for narratives that center around false, inaccurate, and misinformed beliefs and views (Ecker et al. 2022). In this study, the term "misleading narratives" specifically refers to these narratives, such as conspiracy theories and propaganda. These narratives are collections of disinformation pieces structured in a way that tells a coherent, albeit false or misleading, story. Douglas and Sutton (2023) explain that a conspiracy theory is built upon a belief that malicious actors secretly coordinate to achieve their nefarious goals. Ellul (1973) defined propaganda as the deliberate expression of opinions or actions by individuals or groups, aimed at influencing the opinions or actions of other individuals or groups for predetermined purposes. These definitions highlight the importance of maintaining coherence and consistency in the formation and spread of misleading narratives. Sharing the same belief in the digital space is often achieved by drawing information from shared sources, as examples of conspiracy theories and political polarization show (Bakshy, Messing, and Adamic 2015; Yang et al. 2020).

1.1.1 Conceptualizing signature information sources of a misleading narrative

The current research aims to identify signature sources of a misleading narrative, which encompass low-credibility sources and niche sources. Specifically, signature sources are defined as a subset of information sources among those used by online communities discussing a misleading narrative. This subset includes sources known to generate low-credibility information and those exclusively used for a specific misleading narrative but not for general public discourse. By capturing untrustworthy sources especially influential for a narrative, and uncommon sources used exclusively by the narrative but not by others (e.g., theflatearthsociety.org for the flat earth conspiracy theory or illuminatiofficial.org for the Illuminati conspiracy theory), we may be able to extract distinctive patterns of information flow that characterize the narrative and groups promoting it.

Signature sources may play a critical role in shaping social media discussions surrounding a misleading narrative. Low-credibility sources and niche sources may act as the epicenter of a specific narrative, generating information that is then reinforced, amplified, and spread by the online community (Zeng and Schäfer 2021; Zimdars, Cullinan, and Na 2023). Moreover, these sources may serve as "breeding grounds" dedicated to a certain narrative, providing necessary infrastructures to monetize, attract audiences, and mobilize actions that further promote the narrative (Ballard et al. 2022; Sullivan 2019). Given that misleading narratives often mix information from various issues and topics to support their argument (Zuckerman 2019), the use of signature sources may help highlight a select set of potential issues that can reach and influence a larger audience. A narrative's rapid and widespread dissemination is often directly linked to sources they cite (Grinberg et al. 2019; Kim and Kim 2023), and the use of these important and characteristic sources may enhance user engagement with the content and induce certain reactions from the public. Thus, the present research explores if signature sources of a misleading narrative can shape the issues discussed in the narrative. It also investigates if signature sources can influence the user engagement of a misleading narrative.

From a practical standpoint, exploring these questions can provide insights into the tactics employed to generate and promote misleading narratives, aiding in the development of strategies to debunk their claims and counter their propagation. For instance, if it is determined that a conspiracy theory relies heavily on unsubstantiated information disseminated by a particular organization, resources can be allocated to thoroughly scrutinize key claims of the organization, monitor its new activities, and minimize its impact on other groups and individuals. This approach could be especially useful and effective when a growing influence of a misleading narrative is anticipated and prompt efforts to counteract the growth are expected, such as with the QAnon conspiracy theories during the 2020 US Presidential Election campaigns and anti-vaccine narratives during the COVID-19 vaccine rollout (EIP 2021; The Virality Project 2022). However, despite the potential value of this approach, there has been limited attention directed toward identifying distinct sources used by proponents of deceptive narratives.

1.1.2 Comparing signature sources of a misleading narrative with legitimate sources

Misleading narratives may also incorporate information from legitimate and credible sources. Online discussions of these narratives draw on and combine information from multiple sources, which can range from online forums full of extreme and far-fetched claims, to legacy media, and to credible information sources such as government sites. Although previous studies have investigated the use of fake news outlets and extreme information sources in the propagation of misleading narratives (Grinberg et al. 2019;

Guess, Nyhan, and Reifler 2020), the mixing of information could make conspiracy theories more convincing and allow them to resonate with the public. By weaving in information from various sources, misleading narratives may present themselves as provocative yet rational and well-founded, leading to their perceived credibility among a broader audience. For instance, when a conspiracy theory selectively uses data from reputable scientific studies or critiques government activities based on official documents, it can create an illusion of evidence-based argumentation. Hence, it is essential to comprehend the extent to which the discussion of a misleading narrative depends on information from reliable sources. Investigating the role of reliable sources could deepen our understanding of misleading narratives in digital spaces, despite the current scarcity of empirical evidence on this issue. This research thus examines how much the discussion of misleading narratives relies on information from legitimate news sources and government sources, and if the narratives gain traction from online communities when they reference these reliable sources.

1.2 Conspiracy theories and the 'Chemtrail' case

To examine the existence and potential role of signature sources, we conducted a case study focusing on a specific misleading narrative, the "Chemtrail" conspiracy theory. Conspiracy theories are one of the most prevalent and influential forms of misleading narratives (Douglas and Sutton 2023). Understanding key factors driving their dissemination and influence is thus crucial, and it requires an investigation of conspiracy theories within the broader information ecosystem.

Conspiracy theories are defined as "attempts to explain the ultimate causes of significant social and political events and circumstances with claims of secret plots by two or more powerful actors" (Douglas et al. 2019, 4). Baden and Sharon (2021, 82) also note that conspiracy theories "assume conspirators' pervasive control over events and information." The Chemtrail theory, which falsely claims that the trails in the sky behind airplanes are not just water vapor, but are actually chemicals or biological agents—"chemical trails" or "chemtrails"—being spread on purpose by government agencies or others for sinister reasons, fits within the framework of conspiracy theories. This theory is recognized as one of the major conspiracy theories and has been the subject of academic and journalistic investigations (Coleman 2022; Fountain 2016; Mahl, Zeng, and Schäfer 2021; Tingley and Wagner 2017). Proponents of the theory often argue that these trails are part of a larger, covert geoengineering project aimed at manipulating Earth's climate, which intertwines the narrative with legitimate scientific concepts and debates and makes it more challenging to debunk. Despite various efforts by government agencies and research institutions to correct the misbeliefs (Cercone 2023; Fountain 2016; Shearer et al. 2016), the narrative persists. An analysis of Google search trends indicates that searches for "chemtrail" are almost equivalent to those for "contrail" and significantly outnumber those for "condensation trail," the accurate terms for vapor trails (see Figure S1 in the online supplementary information). Its prevalence and persistence underscore the need for a deeper understanding of the mechanisms driving the spread and acceptance of the enduring narrative (Tingley and Wagner 2017). The volume of the content analyzed in this study further demonstrates the conspiracy theory's endurance over a decade (see the online supplementary information).

The selection of the Chemtrail conspiracy theory for this study is due to not only its prevalence and persistence, but also its intersection with several domains: environment, science, health, politics, and religion (Cercone 2023; Fountain 2016; Tingley and Wagner 2017). Specifically, the narrative taps into environmental concerns about air quality and ecological impact. It also raises fears and anxieties about airborne toxins affecting human health. Political ideologies permeate the discussions, with elites, politicians,

and government agencies often portrayed as malevolent actors. The narrative often intertwines with religious beliefs and interpretations, resulting in criticism of actions that disrupt the "god-given" environment. This versatility allows the narrative to bridge suspicion and distrust in one domain to the other, further enhancing its reach and impact.

The targeted examination of a particular conspiracy theory can also serve dual purposes. First, an in-depth investigation into a specific conspiracy theory provides invaluable insights into the complex interactions among actors and the information flow network that serves as the breeding ground for the conspiracy theory. A focused exploration of a particular theory, compared with top-down approaches adopted by a number of previous studies investigating the general landscape of online misinformation (González-Bailón et al. 2023; Hosseinmardi et al. 2021; Miani, Hills, and Bangerter 2022), can offer more pragmatic knowledge and tangible tools that can be directly applied to identify the activities of such narratives and combat their potential rise in reach and influence. For example, rigorous targeted investigations can help identify distinct information sources used by a certain misleading narrative, and these characteristic information sources can help stakeholders, such as policymakers, educators, and social media platforms, in monitoring, counteracting, and possibly preventing the spread of false narratives. This objective is particularly important in the case of the Chemtrail conspiracy theory, given its persistent presence, existing connections to multiple domains, and potential impacts of its further proliferation in the future.

Second, by delving into the details of a specific case, we can begin to uncover patterns that might be applicable to other misleading narratives. This is important given that people who believe in one conspiracy theory are often inclined to believe in others (Douglas and Sutton 2023; Ecker et al. 2022; Goertzel 1994). Furthermore, claims of conspiracy theories are connected to others, and this interconnectedness serves to reinforce belief systems and can lead to the formation of communities that perpetuate a myriad of misleading narratives (Miani, Hills, and Bangerter 2022). Thus, by conducting an in-depth examination of one conspiracy theory, this research aims to provide a building block of knowledge that enables better recognition and understanding of other conspiracy theories and the broader disinformation ecosystem.

The present research was guided by a set of research questions. How frequently are signature sources used among online communities engaging in misleading narratives? What role do signature sources play in influencing the user engagement of these messages on social media platforms? How do these sources shape the content, tone, and reactions to a misleading narrative? What insights can be drawn from the case of the Chemtrail conspiracy theory to inform strategies to monitor and counter the spread of similar misleading narratives?

2 Methods

2.1 Data collection

We employed CrowdTangle (CT), a social media analytics tool owned and managed by Facebook's parent company, Meta, to collect information about online communities engaging in discussions related to the Chemtrail conspiracy theory. CT offers researchers the capability to access the historical data of more than seven million Facebook Pages, Groups, and verified profiles that meet its data collection criteria (CrowdTangle Team 2021b, 2021a). To our best knowledge, CT is the only tool that researchers external to Facebook can use to search for specific Facebook Pages and Groups and retrieve their

content.

We utilized the search feature in CT's web-based interface to identify Facebook Pages and Groups that included any of the following search phrases in their titles: "chemtrail," "chem trail," "chem-trail," "chemical AND trail," "secret AND atmospher AND program," "spray AND spher," "sprayops," and "they AND spray." Using CT's Post Search API, we retrieved English posts created by these Pages and Groups between January 2010 and April 2023. (In this research, the terms "post" and "message" were used interchangeably when referring to the collected Facebook content. Also, this research used the term "accounts" to collectively refer to both Facebook Pages and Groups.)

We then filtered out accounts that did not align with the research scope, such as groups and organizations in the music and entertainment domain that include "chemtrail" in their names but are irrelevant to the conspiracy theory. This was achieved by eliminating Pages and Groups containing any of the music-related or entertainment-related terms ("music," "rock," "punk," "band," "guitar," "jazz," or "entertainment") in their page description, without the presence of words hinting at a potential relation to the Chemtrail theory, such as "weather," "conspiracy," or "sky," either in their page description or account name.

As a result, we obtained a total of 137,140 posts originating from 784 accounts. The present research considered each of these Facebook Pages and Groups as an online Chemtrail community where community members share a common interest and view centered around the conspiracy theory. Example names and posts from these communities are presented in Table 1 on the following page.

The data for this research were gathered from publicly accessible Facebook Pages and Groups, in compliance with the platform's terms and conditions and CrowdTangle's guidelines. No private or individual user data were accessed during the research. We recognize the sensitive nature of investigating online communities, particularly those engaging in misleading narratives.

2.2 Categorization of information sources

We evaluated information sources used in online communities by extracting URLs (Uniform Resource Locators) present in their posts and identifying their respective domains. When users generate content on Facebook, they frequently combine information from a range of sources. A single post can include multiple URLs, and we extracted all URLs contained in each post. We then classified the top-level domains of all the URLs. For example, the top-level domain of the URL "https://www.weather.gov/fgz/cloudscontrails" is "weather.gov," which is a government information source. We checked if a top-level domain corresponds to one of the two known types of information sources: government sources and legitimate news sources.

Specifically, first, we checked if a URL indicated the use of a government source by matching its top-level domain with any from the list of 15,774 government domains. This list was compiled from multiple sources, including the list of .gov domains provided on Gsa.gov (2014), non-.gov domains managed by the US government listed on Search.gov (2019), a list of .mil domains (Sonderegger 2015), and 87 international government domains listed on Wikipedia (2021). If the top-level domain of a URL corresponded to a government domain (e.g., nih.gov, whitehouse.gov), we considered the URL as indicating the use of a government source.

Second, we determined whether a URL indicated the use of a news source by checking if its domain matched any of the domains in our compilation of news domains. This compilation included "Hard news domains" mentioned in Bakshy, Messing, and Adamic

Table 1: Examples of Facebook Page and Group Names and Their Content

Example community name	
"... Chemtrail Watchers"	"Stop Chemtrails ..."
"Chemtrail hunters of ..."	"... March Against Chemtrails..."
"The Anti Chemtrail Coalition of ..."	"Geoengineering ..."
"... Chemtrail Evidence"	"... Against Chemtrails"
"Chemtrails Activity Worldwide"	"Chemtrails & HAARP ..."
"... Chemtrail Cover-up"	"Weather Modification/Harp/.../Chemtrails"
Example posts	
"Can't even have a good meal without getting poisoned from above ..."	
"... Covertly, insidiously, mercilessly, a global depopulation agenda has been launched. ..."	
"... I read that insurance companies were instrumental for geo-enginering and chemtrails to be put in practice ..."	
Example health-related messages	
"Smears across the entire sky ... allergies been acting up for days now ..."	
"...I believe the chemtrails are responsible for a chemical intoxication of the public, which would then cause a general immune suppression...", told Dr. Horowitz."	
Example death-related messages	
"Millions die from air pollution: The World Health Organisation says an estimated seven million people died as a result of air pollution ... Chemtrails?"	
"They are going to try to kill us all."	

Note. The sections indicated by "..." have been omitted to maintain anonymity. Additionally, certain original content and format, such as capitalization and punctuation, have been altered or deleted for the sake of anonymity, conciseness, and clarity.

(2015), "News media sites" identified in Yang et al. (2020), "Newspapers" and "Digital-native news outlets" labeled by Pew Research Center (Perrin and Anderson 2019), as well as "Green" and "Yellow" domains classified by Grinberg et al. (2019).

2.2.1 Signature sources

Among information sources used by conspiracy theory communities, we classified certain sources as signature sources. These include two categories: (1) known sources of information with low credibility and (2) niche sources of information exclusively used by the conspiracy communities and not frequently cited elsewhere.

First, the list of low-credibility sources was compiled by merging sources categorized as "Black," "Red," or "Orange" in Grinberg et al. (2019); those labeled as "very low credibility" and "low credibility" by Media Bias and Fact Check, a website that evaluates the bias and credibility of media sources (Media Bias/Fact Check 2023); and the list of "disinformation domains" documented by Lasser et al. (2022).

Second, to identify niche sources, we located sources that are not visited by a large number of general internet users. This was accomplished by eliminating sources recognized by two separate organizations as domains with the highest number of visits: Alexa's online list of top-ranking sites (see the online supplementary information for details) and Cisco's Umbrella Popularity List (Cisco 2016). We extracted the 10,000 most popular domains from each list and combined them to create a list of common information sources. Sources that were cited by at least 5% of the Chemtrail communities but were not included in the common sources list were labeled as niche sources.

In the present study, information sources identified as either low-credibility or niche sources were classified as signature sources. We verified that applying a different criterion for common sources, such as considering the 1,000 most popular domains from the two lists, does not significantly alter the list of niche sources and, consequently, that of signature sources. See Table S1 in the online supplementary information.

We excluded common sources from signature sources. Common sources, such as google.com and amazon.com, function as fundamental components of the information ecosystem that enable the formation and maintenance of a wide range of topics, narratives, and collective movements. Thus, their importance is not necessarily limited to a specific misleading narrative. Examining the common sources and identifying their roles is a crucial but separate task from the goal of the present research, which aims to identify the roles of distinctive and more characteristic sources used for a certain misleading narrative. In fact, common sources merit dedicated, in-depth investigations, since these sources often provide multiple services and functions (such as google.com and amazon.com) and host diverse users and groups generating their own content (such as youtube.com and instagram.com).

2.3 Outcome variables

We investigated the influence of signature sources on the characteristics and engagement outcomes of social media posts. Specifically, we examined the relations between the inclusion of these sources in a post and the following factors: the post's alignment with particular themes, the post's tone and emotion, and the level of user engagement of the post.

We assessed the health-relatedness of each message by calculating the proportion of words associated with health in the message. We also measured illness-, death-, risk-, politics-, and religion-relatedness by calculating the proportion of words related

to each issue. For these measurements, we utilized LIWC-22, a specialized software for analyzing word usage (Boyd et al. 2022). The levels of negative tone, positive tone, negative emotion, and positive emotion were also determined using LIWC-22.

We analyzed multiple engagement measures, including the number of shares, likes, positive reactions, and negative reactions obtained by a post. In the present research, user engagement refers to these four types of interactions. Positive reactions are the sum of the counts of "thankful," "care," "love," and "haha" responses received by a post. Negative reactions are the sum of the counts of "sad" and "angry" responses received by a post.

2.4 Statistical analysis

We utilized statistical methods to examine the associations between the use of information sources, and the content and dissemination of messages. In these evaluations, we accounted for different attributes of the articles such as the length of the articles and the year they were published, along with characteristics related to the account such as the size of the subscriber base and the type of account. We estimated regression models to examine the association between potential predictors and outcomes. Standard errors were clustered at the account level. All models were estimated with cluster-robust standard errors to account for the correlation of posts within the same account. Specifically, in the context of engagement evaluation, we estimated negative binomial regression models, which suit the imbalanced distribution usually seen in social media engagement data (Brady et al. 2017; Brady et al. 2019; Rathje, Van Bavel, and Linden 2021). Incident Rate Ratios (IRRs) were calculated by taking the exponent of the coefficients in each model. An IRR exceeding 1 indicates a positive association, whereas a value below 1 indicates a negative association. For other outcome variables, we estimated linear regression models and reported regression coefficients of the models. All statistical analyses were performed using the Statsmodel package in Python (Seabold and Perktold 2010).

3 Results

The descriptive statistics of post and account characteristics are presented in Table 2. On average, a message was shared 1.99 times (*SD* = 35.40) and received 3.82 likes (*SD* = 23.01). A message also received on average 0.37 positive reactions (*SD* = 7.38) and 0.50 negative reactions (*SD* = 5.31). Including information sources in messages was a common practice, with approximately 84.9% of the messages incorporating at least one information source. Specifically, 2.3%, 6.5%, and 7.2% of messages cited one or more government information sources, news sources, and signature sources, respectively. The results demonstrate that the presence of signature sources is not negligible compared with the two types of reliable sources. Facebook Pages made up 73.6% of all accounts in the dataset, while the remaining comprised Facebook Groups. Example posts created by the Chemtrail online communities are presented in Figure S2 in the online supplementary material.

3.1 Signature sources of the Chemtrail conspiracy theory

Table 3 lists the signature sources of the Chemtrail narrative. Each source was referenced by at least 5% of the communities. The table also presents the prevalence of each signature source, which corresponds to the proportion of communities that referenced a certain signature source one or more times, among all Chemtrail communities. The prevalence was calculated based on the proportion of communities, rather than the

Table 2: Descriptive Statistics

Characteristics	Statistics
Message characteristics (*N* = 137,140)	
Number of shares, *M* (*SD*)	1.99 (35.40)
Number of likes, *M* (*SD*)	3.82 (23.01)
Number of positive reactions, *M* (*SD*)	0.37 (7.38)
Number of negative reactions, *M* (*SD*)	0.50 (5.31)
Number of characters in a message, *M* (*SD*)	442.56 (762.94)
Number of URLs in a message, *M* (*SD*)	1.39 (1.88)
Proportion including any information sources	84.9%
Proportion including one or more government sources	2.3%
Proportion including one or more news sources	6.5%
Proportion including one or more signature sources	7.2%
Health-relatedness, *M* (*SD*)	0.91 (3.10)
Illness-relatedness, *M* (*SD*)	0.38 (1.86)
Death-relatedness, *M* (*SD*)	0.25 (1.52)
Risk-relatedness, *M* (*SD*)	0.36 (1.76)
Politics-relatedness, *M* (*SD*)	0.83 (2.46)
Religion-relatedness, *M* (*SD*)	0.23 (1.72)
Account characteristics (*N* = 784)	
Number of subscribers, *M* (*SD*)	458.64 (3856.86)
Account type (Facebook Page)	73.6%

proportion of posts, to minimize the chance that a source used heavily by only a few communities but not by others is evaluated as broadly referenced. The most frequently referenced signature source was geoengineeringwatch.org, which was used by 25.1% of all online communities discussing the conspiracy theory.

We examined whether any of these sources are low-credibility sources. The four most frequently referenced signature sources appeared to be low-credibility sources: geoengineeringwatch.org, activistpost.com, beforeitsnews.com, and dailymail.co.uk. However, it is noteworthy that 11 out of the 30 signature sources (36.7%) were not low-credibility sources. For instance, although climateviewer.com (also known as ClimateViewer News) had not been categorized as a low-credibility source, it appeared as a significant source for the Chemtrail narrative, with 9.3% of the Chemtrail communities referencing it. The website publishes content related to Chemtrail, weather alteration, and geoengineering, and Chemtrail communities not only referenced articles from the source but also used an interactive map service affiliated with the site, climateviewer.org (also known as ClimateViewer Maps). Some representative messages referencing climateviewer.com are as follows: “The chemtrail conspiracy bombshell! Secret agenda explained! Articles from video: https://climateviewer.com...,” and “...Please see anyone who has had cause for concern re chemtrails/geoengineering ... http://climateviewer.com/chemtrails/.” Another crucial example is globalmarchagainstchemtrailsandgeoengineering.com (“Globalmarch” hereafter), which has been converted into a gambling site as of July 2023. Although it had not been captured as a low-credibility source in previous work, the analysis revealed that 8.9% of the Chemtrail communities had referenced this source. Examples of Chemtrail messages referencing this source include “Register your global march against chemtrails and geoengineering educational event with us today...[a link to Globalmarch]” and “Those lines in the sky are not clouds... Next global march against chemtrails and geoengineering...[a link to Globalmarch].”

It is worth noting that some of the signature sources do not conform to the traditional definition of “disinformation spreaders.” For example, avaaz.org, a nonprofit organiza-

Table 3: Signature Information Sources of the Chemtrail Narrative

Index	Information Sources	Prevalence (%)	Issue-focused[a]
1	geoengineeringwatch.org	25.1	Yes
2	activistpost.com	10.8	
3	beforeitsnews.com	10.1	
4	dailymail.co.uk	9.9	
5	globalskywatch.com	9.6	Yes
6	climateviewer.com*	9.3	Yes
7	infowars.com	9.1	
8	globalmarchagainstchemtrailsandgeoengineering.com*	8.9	Yes
9	gmacag.com*	8.8	Yes
10	globalresearch.ca	8.7	
11	rt.com	8.3	
12	worldtruth.tv	8.2	
13	aircrap.org*	8.0	Yes
14	yournewswire.com	7.9	
15	collective-evolution.com	7.8	
16	avaaz.org*	7.7	
17	bitchute.com	7.5	
18	stopsprayingus-sf.com*	7.1	Yes
19	rense.com	6.5	
20	zengardner.com*	6.3	
21	blogtalkradio.com*	6.1	
22	thetruthdenied.com*	6.1	
23	carnicominstitute.org*	5.7	
24	whyintheworldaretheyspraying.com*	5.6	Yes
25	thelibertybeacon.com	5.4	
26	humansarefree.com	5.4	
27	wakeup-world.com	5.2	
28	stateofthenation2012.com	5.2	
29	rumble.com	5.1	
30	wakingtimes.com	5.1	

[a] Information sources were identified as issue-focused if their content focused on the Chemtrail conspiracy theory; unsubstantiated concern of condensation trail, weather modification, and geo-engineering; or the denial of climate change.

Note. Prevalence indicates the proportion of communities that referenced a certain signature source one or more times, among all Chemtrail communities. Information sources marked with * are sources that have not been included in the list of low-credibility information sources. The list presented in this table is composed of disinformation sources and niche sources, and the latter excluded the 10,000 most popular sources on the Internet. All sources were used by more than 5% of the Chemtrail communities.

tion that promotes global activism, was used by multiple Chemtrail communities in expressing their support for online petitions against Chemtrail, such as "Worldwide petition: Ban Chemtrails and HARRP now! ... https://secure.avaaz.org/en/petition/..." and "...Please sign and share. Stop the Chemtrails! ... http://www.avaaz.org/en/petition/..." Another example is blogtalkradio.com, an online radio hosting platform (Kurtz 2008). The platform was used by the communities to draw attention to radio programs discussing Chemtrail, such as "Join us tonight at 8 PM EST when [a person] joins us again to talk about chemtrails and the events coming on this earth that will shake this world to its core... http://blogtalkradio.com/..." and "Today we will be discussing chemtrails and the people covering up the largest conspiracy this planet has ever known .... blogtalkradio.com."

We also found that a considerable proportion of the signature sources not classified as low-credibility focused specifically on issues close to Chemtrail: Five out of the 11 sources not identified as low credibility dealt with Chemtrail and related issues, such as weather modification, HAARP (the High-frequency Active Auroral Research Program), and geoengineering. This highlights the efficacy of the present methodological approach, capturing conspiracy theory communities' frequent references that have largely eluded scholarly and journalistic attention due to their narrow focus and limited audience. Contrarily, only three out of 19 sources that were identified as low credibility focused exclusively on these topics. In all, five out of the eight sources focusing on Chemtrail-related issues were not classified as low-credibility sources.

3.2 Association of signature sources with message characteristics and engagement

Messages using signature sources contained more health-, illness-, risk-, and death-related words than those without signature sources. Table 4 (p. 14) presents the association between information sources and the proportion of words related to each theme. First, compared with messages without signature sources, those incorporating signature sources had more words related to health (B = 0.436, SE_B = 0.135, p = .001), illness (B = 0.332, SE_B = 0.117, p = .004), risk (B = 0.187, SE_B = 0.042, p < .001), death (B = 0.106, SE_B = 0.037, p = .004), and politics (B = 0.212, SE_B = 0.075, p = .005), controlling for message length; inclusion of photos or videos; inclusion of legitimate news sources, government sources, or Facebook internal sources (i.e., Facebook domains such as facebook.com); and year, account type, and number of subscribers. When compared with other source types, only signature sources were positively associated with health-related content. On the other hand, messages including signature sources had fewer words related to religion (B = -0.086, SE_B = 0.015, p< .001).

To test the robustness of the above findings, we examined different criteria of signature sources. In this analysis, we varied the minimum proportion of online communities by which a source should be referenced to be qualified as a signature source: 3%, 5%, and 7%. The comparison supports the robustness of the results across different criteria, as shown in Table S2 of the online supplementary information.

News, government, and Facebook internal sources, on the other hand, showed different association patterns. Particularly, messages containing legitimate news sources had more words related to illness (B = 0.341, SE_B = 0.152, p = .025), death (B = 0.139, SE_B = 0.038, p < .001), risk (B = 0.188, SE_B = 0.036, p < .001), and politics (B = 0.715, SE_B = 0.084, p < .001), compared with those without legitimate news sources. Messages with government sources contained more politics-related words (B = 1.112, SE_B = 0.187, p < .001) but fewer religion-related words (B = -0.160, SE_B = 0.021, p < .001), compared with messages without government sources. On the contrary, messages referencing

Facebook internal sources were negatively associated with all word groups: politics (B = -0.333, SE_B = 0.047, p < .001), health (B = -0.304, SE_B = 0.080, p < .001), illness (B = -0.203, SE_B = 0.073, p = .005), death (B = -0.105, SE_B = 0.025, p < .001), and religion (B = -0.047, SE_B = 0.020, p = .021).

Messages incorporating signature sources generally conveyed more negativity, as evidenced by a higher proportion of words related to negative tone, and a lower proportion of words related to positive tone and positive emotion, compared with messages not referencing signature sources. Table 5 shows the tones and emotions of messages. It indicates that the inclusion of signature sources was associated positively with the proportion of words related to negative tone (B = 0.911, SE_B = 0.312, p = .003), and negatively with the proportion of words related to positive tone (B = -1.350, SE_B = 0.287, p < .001) and positive emotion (B = -0.590, SE_B = 0.234, p = .012), respectively. Legitimate news sources were associated with less positive tone (B = -1.272, SE_B = 0.271, p < .001) and emotion (B = -0.550, SE_B = 0.201, p = .006). Government sources were associated with less positive tone (B = -1.133, SE_B = 0.106, p < .001) and emotion (B = -0.373, SE_B = 0.081, p < .001), and also more negative tone (B = 0.344, SE_B = 0.141, p = .015) and emotion (B = 0.700, SE_B = 0.157, p < .001). On the contrary, Facebook internal sources were not associated with any of these metrics.

The associations between the inclusion of information sources and user engagement metrics are presented in Table 6. No significant association was found between the use of signature sources, and re-shares and likes. This indicates that messages including signature sources and messages not including them did not show a significant difference in these metrics. Also, there was no statistical difference in positive reactions depending on the inclusion of signature sources. However, including signature sources was associated with more negative reactions to the messages (IRR = 3.881, 95% CI [1.225, 12.296], p = .021), while legitimate news sources and government sources were not significantly associated with negative reactions. Government sources appeared to be associated with a reduced number of likes (IRR = 0.525, 95% CI [0.363, 0.759], p < .001) and positive reactions (IRR = 0.134, 95% CI [0.050, 0.354], p < .001).

4 Discussion

The present research underscores the importance of identifying unique information sources of misleading narratives, highlighting their potential influence in shaping the content and tone of these narratives. Based on the case study of the Chemtrail conspiracy theory, this research identified four key findings, outlined below.

First, signature sources have a significant presence within online communities engaged in the discussion of a misleading narrative. In the context of the Chemtrail narrative, these distinctive sources were used by more communities than were legitimate news sources and government sources. Also, these sources extend beyond the originators of misinformation and disinformation, encompassing digital infrastructures that facilitate and amplify the propagation of certain misleading narratives and the promotion of activism and policy changes that arise in response. Examples of the sources providing digital infrastructures include map visualization tools, fundraising websites, and online petition platforms. This finding suggests the importance of expanding scholarly discussions on disinformation to consider the broader information ecosystem and digital infrastructures.

This finding also implies that a more comprehensive and refined mapping of information ecosystems could enhance the understanding of the current digital landscape. While there has been significant progress in expanding lists of low-credibility sources, focusing

Table 4: Message Content as a Function of the Inclusion of Information Sources

Independent variables	Issues in the message					
	Health-related	Illness-related	Death-related	Risk-related	Politics-related	Religion-related
Key predictors						
Signature source	0.436 (0.135)**	0.332 (0.117)**	0.106 (0.037)**	0.187 (0.042)***	0.212 (0.075)**	−0.086 (0.015)***
Legitimate news source	0.247 (0.141)	0.341 (0.152)*	0.139 (0.038)***	0.188 (0.036)***	0.715 (0.084)***	−0.041 (0.022)
Government source	−0.204 (0.105)	−0.057 (0.081)	−0.048 (0.027)	0.034 (0.030)	1.112 (0.187)***	−0.160 (0.021)***
Message-level covariates						
Facebook internal source	−0.304 (0.080)***	−0.203 (0.073)**	−0.105 (0.025)***	−0.069 (0.036)	−0.333 (0.047)***	−0.047 (0.020)*
Year	0.083 (0.040)*	0.066 (0.027)*	0.001 (0.005)	0.002 (0.007)	0.022 (0.018)	0.013 (0.004)**
Message length	0.064 (0.026)*	0.012 (0.015)	0.003 (0.006)	0.022 (0.014)	0.183 (0.023)***	0.002 (0.007)
Including photo	−0.214 (0.064)***	−0.087 (0.036)*	0.040 (0.024)	0.002 (0.046)	−0.268 (0.104)*	0.037 (0.030)
Including video	−0.321 (0.065)***	−0.127 (0.039)**	0.043 (0.021)*	−0.057 (0.025)*	−0.115 (0.094)	0.025 (0.028)
Account-level covariates						
Account type	0.167 (0.206)	0.120 (0.112)	0.049 (0.040)	−0.031 (0.053)	−0.079 (0.165)	−0.043 (0.042)
Subscriber size	−0.015 (0.008)	−0.005 (0.007)	−0.005 (0.002)*	0.013 (0.008)	−0.007 (0.005)	−0.003 (0.001)*
Constant	0.590 (0.201)**	0.051 (0.133)	0.228 (0.038)***	0.363 (0.057)***	0.830 (0.155)***	0.187 (0.025)***

Note. N = 137,140 grouped within 784 communities. Statistical significance is indicated by *p < .05, **p < .01, and ***p < .001. The standard errors are shown within parentheses. The length of a message is calculated by dividing the number of characters in a message by 1,000, while the subscriber size is determined by dividing the number of subscribers of an account by 1,000. The "Year" variable ranges from 0 (representing the year 2010) to 13 (representing the year 2022) and is represented as an integer. The account type is categorized as 1 if it is a Facebook Page and 0 if it is a Facebook Group. Standard errors were clustered at the account level. All models were estimated with cluster-robust standard errors. Signature sources were defined as those cited by more than 5% of communities.

Table 5: Tone and Emotion as a Function of the Inclusion of Information Sources

Independent variables	Outcome variables: Tone and emotion in the message			
	Negative tone	Positive tone	Negative emotion	Positive emotion
Key predictors				
Signature source	0.911 (0.312)**	−1.350 (0.287)***	0.663 (0.350)	−0.590 (0.234)*
Legitimate news source	0.333 (0.268)	−1.272 (0.271)***	−0.116 (0.313)	−0.550 (0.201)**
Government source	0.344 (0.141)*	−1.133 (0.106)***	0.700 (0.157)***	−0.373 (0.081)***
Message-level covariates				
Facebook internal source	−0.089 (0.151)	0.088 (0.140)	0.136 (0.169)	0.137 (0.127)
Year	0.009 (0.021)	0.154 (0.063)*	−0.015 (0.026)	0.102 (0.056)
Message length	−0.091 (0.066)	−0.535 (0.089)***	−0.124 (0.071)	−0.296 (0.078)***
Including photo	−0.121 (0.257)	−1.050 (0.518)*	−0.249 (0.277)	−0.514 (0.415)
Including video	0.109 (0.286)	−0.597 (0.208)**	0.021 (0.324)	0.014 (0.093)
Account-level covariates				
Account type	0.580 (0.297)	−0.760 (0.336)*	0.610 (0.326)	−0.532 (0.265)*
Subscriber size	−0.044 (0.014)**	0.221 (0.212)	−0.023 (0.013)	0.219 (0.203)
Constant	2.321 (0.237)***	2.967 (0.320)***	1.163 (0.242)***	0.649 (0.140)***

Note. N = 137,140 articles grouped within 784 communities. Statistical significance is indicated by *p < .05, **p < .01, and ***p < .001. The 95% confidence intervals (CIs) are shown within square brackets. The length of a message is calculated by dividing the number of characters in a message by 1,000, while the subscriber size is determined by dividing the number of subscribers of an account by 1,000. The "Year" variable ranges from 0 (representing the year 2010) to 13 (representing the year 2022) and is represented as an integer. The account type is categorized as 1 if it is a Facebook Page and 0 if it is a Facebook Group. Standard errors were clustered at the account level. All models were estimated with cluster-robust standard errors. Signature sources were defined as those cited by more than 5% of communities.

Table 6: User Engagement Metrics as a Function of the Inclusion of Information Sources

Predictors	Outcome variables: Virality and reactions			
	Re-shares	Likes	Negative Reactions	Positive Reactions
Key predictors				
Signature source	1.657 [0.963, 2.854]	1.518 [0.704, 3.273]	3.881 [1.225, 12.296]*	0.497 [0.219, 1.128]
Legitimate news source	1.261 [0.838, 1.897]	0.807 [0.605, 1.076]	1.367 [0.825, 2.265]	0.792 [0.438, 1.430]
Government source	0.950 [0.607, 1.486]	0.525 [0.363, 0.759]***	0.737 [0.248, 2.191]	0.134 [0.050, 0.354]***
Message-level covariates				
Facebook internal source	1.675 [1.110, 2.527]*	1.437 [1.147, 1.800]**	2.816 [1.745, 4.544]***	1.756 [1.309, 2.357]***
Year	1.095 [0.987, 1.214]	0.940 [0.877, 1.009]	1.390 [1.265, 1.526]***	1.402 [1.244, 1.580]***
Message length	1.080 [0.945, 1.233]	0.882 [0.786, 0.990]*	0.556 [0.401, 0.771]***	0.798 [0.639, 0.995]*
Including photo	1.322 [0.845, 2.069]	1.424 [1.105, 1.834]**	0.876 [0.564, 1.359]	2.322 [1.451, 3.716]***
Including video	1.599 [1.124, 2.276]**	0.907 [0.705, 1.166]	0.952 [0.650, 1.394]	0.682 [0.480, 0.970]*
Account-level covariates				
Account type	9.075 [5.188, 15.877]***	1.842 [1.099, 3.086]*	1.724 [0.907, 3.279]	4.011 [1.697, 9.479]**
Subscriber size	1.035 [1.001, 1.070]*	1.057 [1.007, 1.110]*	1.018 [0.997, 1.040]	1.063 [1.007, 1.121]*
Constant	0.140 [0.063, 0.310]***	2.816 [1.705, 4.651]***	0.022 [0.010, 0.049]***	0.006 [0.003, 0.016]***

Note. N = 137,140 articles grouped within 784 communities. The coefficients indicate incident rate ratios (IRR) derived from a negative binomial regression model predicting an outcome variable. Statistical significance is indicated by *p < .05, **p < .01, and ***p < .001. The 95% confidence intervals (CIs) are shown within square brackets. The length of a message is calculated by dividing the number of characters in a message by 1,000, while the subscriber size is determined by dividing the number of subscribers of an account by 1,000. The "Year" variable ranges from 0 (representing the year 2010) to 13 (representing the year 2022) and is represented as an integer. The account type is categorized as 1 if it is a Facebook Page and 0 if it is a Facebook Group. Standard errors were clustered at the account level. All models were estimated with cluster-robust standard errors.

solely on these lists may risk overlooking crucial sources that contribute to specific misleading narratives. For example, Hua et al. (2022) found that the use of alternative methods for user monetization is prevalent on digital platforms, and these methods are not captured by the category of low-credibility sources. The finding also indicates that, among a large number of low-credibility sources compiled by previous studies, only a subset of them is tied to a specific misleading narrative. This underscores the value of nuanced categorizations of low-credibility sources, which would help researchers and practitioners refine their approaches. The present study implies potential benefits of categorizing low-credibility sources based on their contributions to distinct narratives.

Although the use of signature sources may hint at the online community's engagement with the misleading narrative, it is not adequate to rely on a single signature source to draw conclusions. For example, the existence of one Chemtrail signature source, especially those covering a wide range of topics like infowars.com or dailymail.co.uk, is insufficient to support the community's engagement with the narrative. On the other hand, the presence of multiple signature sources, especially those closely linked to a specific misleading narrative, can be a strong indicator of the communities' engagement, such as globalskywatch.com and gmacag.com in the Chemtrail case.

The count of signature sources can vary. While this study identified 30 signature sources for the Chemtrail narrative on Facebook, this number may differ across narratives and platforms. The sheer number of signature sources can offer useful insights into the nature of a narrative. A higher count could suggest a more expansive and distinctive pool of information sources than those of other narratives. This variance could stem from multiple factors, such as a stronger reliance on distinct sources or higher consistency in the content disseminated by different communities discussing the same narrative. Hence, the count of signature sources can serve as a useful metric for cross-narrative comparisons.

This study outlines potential methodologies for discovering niche sources, but further research is needed to refine the criteria and develop more sophisticated approaches. Also, if the proposed procedure yields too few or too many signature sources for a misleading narrative, it may be necessary to recalibrate the criteria. The criteria proposed in this study should be viewed as an illustrative example, rather than definitive rules.

It should be highlighted that a considerable portion of messages discussing the Chemtrail conspiracy theory cited legitimate sources and news sources. This blending of sources can complicate the task of distinguishing misleading narratives from typical public discourse, especially for those without the tools or expertise to critically assess information sources. Thus, pathologizing misleading narratives as isolated and solely fringe may impede the capacity to recognize the nuanced ways in which these narratives are constructed and spread. This, in turn, could hamper the development of effective strategies to counter them.

Second, the use of signature sources was associated with more death-, illness-, risk-, and health-related discussions. These sources were also associated with more politics-related discussions. These findings suggest that signature sources might contribute to emphasizing Chemtrail's health dangers and risks, while promoting more politicized discussions. This pattern appeared to be distinct to signature sources, in contrast to legitimate news and government sources exhibiting different associations.

Third, the use of signature sources was associated with the tone and emotion expressed in messages. Specifically, signature sources of the Chemtrail narrative were associated with expressions of greater negativity, such as a more negative tone, a less positive tone, and less positive emotions. Although the inclusion of legitimate news sources and

government sources was also connected with increased negativity, not all information sources or URLs had the same effect. For instance, Facebook internal sources did not exhibit an association with any of the outcomes related to tones and emotions. This suggests that signature sources may play a role in increasing negativity of misleading narratives, a trend that generally aligns with the patterns found for legitimate news sources and government sources.

Fourth, signature sources were associated with more negative reactions. Resonating with the association between signature sources and increased negativity in the content, this finding suggests that content incorporating signature sources might induce greater negative reactions from the audience. Given the inherent distrust and hostility central to the conspiracy theory, and the negative portrayal of public institutions and big corporations promoted by signature sources, it is plausible that these sources exacerbate the online community's negative views and reactions toward alleged malevolent actors implicated in the conspiracy theory. We also found that posts including government sources received fewer likes and fewer positive reactions. This could be indicative of a general mistrust toward the government among consumers of conspiracy theory content (Imhoff and Lamberty 2018; Pierre 2020; Richey 2017), although more evidence should be discovered, as government sources' associations with re-shares and negative reactions were not statistically significant. Furthermore, the inclusion of Facebook internal sources or photos enhanced users' engagement with posts, which is consistent with previous findings (Kim and Kim 2023; Li and Xie 2020).

The findings reported in this research may not be universally applicable to other misleading narratives. Although these findings underscore the significance of signature sources in the Chemtrail case, the prominence and influence of signature sources can manifest differently across misleading narratives. Contextual nuances should be central in interpreting the significance and role of signature sources within specific narratives.

Platform characteristics should also be considered when interpreting the findings. This study focused solely on Facebook, and the status and associations identified here could vary on other platforms. For instance, the influence of signature sources may depend on the platform's emphasis on sharing external sources. On platforms like Facebook, where direct sharing of external sources is prevalent, signature sources may have a more prominent role, compared with other platforms where user-generated content is more commonly found, such as Reddit.

While this research provides valuable insights, it does have certain limitations. First, the findings are based on observational data. Thus, the potential causal relationships suggested in this research are speculative and not definitive, and should be interpreted with caution. Second, the research aimed to explore the discourse surrounding a misleading narrative. While all communities identified in this research discussed the same narrative, not all might support the existence of Chemtrail. Examining the spectrum of opinions, which would likely require different methodologies and research questions, will add a more nuanced understanding. Third, while this research mainly focused on signature sources and contrasted them with two other types of sources, future research should provide more in-depth investigation and discussion of these other sources, their roles and implications, and underlying theories. This will offer a more comprehensive understanding of misleading narratives. Fourth, potential impacts of content moderation could not be considered in this research, due to the lack of access to platform internal policies and operations. It is possible that moderation had suppressed the volume and engagement with conspiracy theory content. Enhanced collaboration between industry and academia, along with better data accessibility, will facilitate more comprehensive research into these aspects. Fifth, the categorization of information sources into "legitimate news sources" could be an oversimplification, considering the complex nature of the online

news ecosystem. Future research should consider a more nuanced categorization of these sources. Lastly, this study did not delve into the temporal dynamics of information dissemination and reception. A more detailed analysis of temporal patterns will provide additional insights into misleading narratives.

5 Conclusion

This study offers an in-depth exploration of the role of information sources in the propagation and reception of misleading narratives on social media, with a specific focus on the Chemtrail conspiracy theory on Facebook. The findings underscore the need for further research to explore the underlying mechanisms and to develop effective strategies to counter these narratives. The insights gained from this study can inform policymakers, scholars, and social media platforms in their efforts to monitor, counteract, and possibly prevent disinformation, thereby fostering a more informed and resilient information ecosystem.

References

Allen, Jennifer, Baird Howland, Markus Mobius, David Rothschild, and Duncan J Watts. 2020. "Evaluating the fake news problem at the scale of the information ecosystem." *Science Advances* 6 (14): eaay3539.

Baden, Christian, and Tzlil Sharon. 2021. "BLINDED BY THE LIES? Toward an integrated definition of conspiracy theories." *Communication Theory* 31, no. 1 (February 11, 2021): 82–106. https://doi.org/10.1093/ct/qtaa023.

Bakshy, E., S. Messing, and L. A. Adamic. 2015. "Exposure to ideologically diverse news and opinion on Facebook." *Science* 348, no. 6239 (June 5, 2015): 1130–32. https://doi.org/10.1126/science.aaa1160.

Ballard, Cameron, Ian Goldstein, Pulak Mehta, Genesis Smothers, Kejsi Take, Victoria Zhong, Rachel Greenstadt, Tobias Lauinger, and Damon McCoy. 2022. "Conspiracy Brokers: Understanding the Monetization of YouTube Conspiracy Theories." In *Proceedings of the ACM Web Conference 2022,* 2707–18. WWW '22. New York, NY, USA: Association for Computing Machinery, April 25, 2022. https://doi.org/10.1145/3485447.3512142.

Boyd, Ryan L., Ashwini Ashokkumar, Sarah Seraj, and James W. Pennebaker. 2022. *The Development and Psychometric Properties of LIWC-22.* Austin, TX: University of Texas at Austin. https://www.liwc.app.

Brady, William J., Julian A. Wills, Dominic Burkart, John T. Jost, and Jay J. Van Bavel. 2019. "An ideological asymmetry in the diffusion of moralized content on social media among political leaders." *Journal of Experimental Psychology: General* 148, no. 10 (October): 1802–13. https://doi.org/10.1037/xge0000532.

Brady, William J., Julian A. Wills, John T. Jost, Joshua A. Tucker, and Jay J. Van Bavel. 2017. "Emotion shapes the diffusion of moralized content in social networks." *Proceedings of the National Academy of Sciences* 114, no. 28 (July 11, 2017): 7313–18. https://doi.org/10.1073/pnas.1618923114.

Cercone, Jeff. 2023. "A video of a former CIA director is not proof that the government is spraying the sky with chemicals." *Poynter* (April 21, 2023). https://www.poynter.org/fact-checking/2023/cia-director-john-brennan-video-chemtrails/.

Cisco. 2016. *Umbrella Popularity List.* https://s3-us-west-1.amazonaws.com/umbrella-static/index.html.

Coleman, Alistair. 2022. "Chemtrails: What's the truth behind the conspiracy theory?" *BBC News* (July 22, 2022). https://www.bbc.com/news/blogs-trending-62240071.

CrowdTangle Team. 2021a. *Citing CrowdTangle Data.* http://help.crowdtangle.com/en/articles/3192685-citing-crowdtangle-data.

———. 2021b. *What data is CrowdTangle tracking?* http://help.crowdtangle.com/en/articles/1140930-what-data-is-crowdtangle-tracking.

Douglas, Karen M., and Robbie M. Sutton. 2023. "What Are Conspiracy Theories? A Definitional Approach to Their Correlates, Consequences, and Communication." *Annual Review of Psychology* 74 (1): 271–98. https://doi.org/10.1146/annurev-psych-032420-031329.

Douglas, Karen M., Joseph E. Uscinski, Robbie M. Sutton, Aleksandra Cichocka, Turkay Nefes, Chee Siang Ang, and Farzin Deravi. 2019. "Understanding Conspiracy Theories." *Political Psychology* 40, no. S1 (February): 3–35. https://doi.org/10.1111/pops.12568.

Ecker, Ullrich K. H., Stephan Lewandowsky, John Cook, Philipp Schmid, Lisa K. Fazio, Nadia Brashier, Panayiota Kendeou, Emily K. Vraga, and Michelle A. Amazeen. 2022. "The psychological drivers of misinformation belief and its resistance to correction." *Nature Reviews Psychology* 1, no. 1 (January): 13–29. https://doi.org/10.1038/s44159-021-00006-y.

Election Integrity Partnership. 2021. *The Long Fuse: Misinformation and the 2020 Election.* V1.3.0. Stanford Digital Repository. https://purl.stanford.edu/tr171zs0069.

Ellul, Jacques. 1973. *Propaganda: The Formation of Men's Attitudes.* New York: Vintage Books. ISBN: 978-0-394-71874-3.

Fountain, Henry. 2016. "Scientists Just Say No to 'Chemtrails' Conspiracy Theory." *The New York Times* (August 15, 2016). https://www.nytimes.com/2016/08/16/science/scientists-just-say-no-to-chemtrails-conspiracy-theory.html.

Goertzel, Ted. 1994. "Belief in Conspiracy Theories." *Political Psychology* 15 (4): 731–42. https://doi.org/10.2307/3791630.

González-Bailón, Sandra, David Lazer, Pablo Barberá, Meiqing Zhang, Hunt Allcott, Taylor Brown, Adriana Crespo-Tenorio, et al. 2023. "Asymmetric ideological segregation in exposure to political news on Facebook." *Science* 381, no. 6656 (July 28, 2023): 392–98. https://doi.org/10.1126/science.ade7138.

Grinberg, Nir, Kenneth Joseph, Lisa Friedland, Briony Swire-Thompson, and David Lazer. 2019. "Fake news on Twitter during the 2016 U.S. presidential election." *Science* 363, no. 6425 (January 25, 2019): 374–78. https://doi.org/10.1126/science.aau2706.

Gsa.gov. 2014. *A complete list of .gov domains.* https://18f.gsa.gov/2014/12/18/a-complete-list-of-gov-domains/.

Guess, Andrew, Jonathan Nagler, and Joshua Tucker. 2019. "Less than you think: Prevalence and predictors of fake news dissemination on Facebook." *Science Advances* 5, no. 1 (January 1, 2019): eaau4586. https://doi.org/10.1126/sciadv.aau4586.

Guess, Andrew, Brendan Nyhan, and Jason Reifler. 2020. "Exposure to untrustworthy websites in the 2016 US election." *Nature Human Behaviour* 4, no. 5 (May): 472–80. https://doi.org/10.1038/s41562-020-0833-x.

Hosseinmardi, Homa, Amir Ghasemian, Aaron Clauset, Markus Mobius, David M. Rothschild, and Duncan J. Watts. 2021. "Examining the consumption of radical content on YouTube." *Proceedings of the National Academy of Sciences* 118, no. 32 (August 10, 2021). https://doi.org/10.1073/pnas.2101967118.

Hua, Yiqing, Manoel Horta Ribeiro, Thomas Ristenpart, Robert West, and Mor Naaman. 2022. "Characterizing Alternative Monetization Strategies on YouTube." *Proceedings of the ACM on Human-Computer Interaction* 6, no. CSCW2 (November 11, 2022): 283:1–283:30. https://doi.org/10.1145/3555174.

Imhoff, Roland, and Pia Lamberty. 2018. "How paranoid are conspiracy believers? Toward a more fine-grained understanding of the connect and disconnect between paranoia and belief in conspiracy theories." *European Journal of Social Psychology* 48, no. 7 (December): 909–26. https://doi.org/10.1002/ejsp.2494.

Kim, Soojong, and Jisu Kim. 2023. "The Information Ecosystem of Conspiracy Theory: Examining the QAnon Narrative on Facebook." *Proceedings of the ACM on Human-Computer Interaction* 7, no. CSCW1 (April 16, 2023): 150:1–150:24. https://doi.org/10.1145/3579626.

Kurtz, Howard. 2008. "With BlogTalkRadio, the Commentary Universe Expands." *Washington Post* (March 24, 2008). http://www.washingtonpost.com/wp-dyn/content/article/2008/03/23/AR2008032301719.html.

Lasser, Jana, Segun Taofeek Aroyehun, Almog Simchon, Fabio Carrella, David Garcia, and Stephan Lewandowsky. 2022. "Social media sharing of low-quality news sources by political elites." *PNAS Nexus* 1, no. 4 (September 1, 2022): pgac186. https://doi.org/10.1093/pnasnexus/pgac186.

Li, Yiyi, and Ying Xie. 2020. "Is a Picture Worth a Thousand Words? An Empirical Study of Image Content and Social Media Engagement." *Journal of Marketing Research* 57, no. 1 (February 1, 2020): 1–19. https://doi.org/10.1177/0022243719881113.

Mahl, Daniela, Jing Zeng, and Mike S. Schäfer. 2021. "From "Nasa Lies" to "Reptilian Eyes": Mapping Communication About 10 Conspiracy Theories, Their Communities, and Main Propagators on Twitter." *Social Media + Society* 7, no. 2 (April 1, 2021): 20563051211017482. https://doi.org/10.1177/20563051211017482.

Media Bias/Fact Check. 2023. "About." Updated May 25, 2023. https://mediabiasfactcheck.com/about/.

Miani, Alessandro, Thomas Hills, and Adrian Bangerter. 2022. "Interconnectedness and (in)coherence as a signature of conspiracy worldviews." *Science Advances* 8, no. 43 (October 26, 2022): eabq3668. https://doi.org/10.1126/sciadv.abq3668.

Munger, Kevin, and Joseph Phillips. 2022. "Right-Wing YouTube: A Supply and Demand Perspective." *The International Journal of Press/Politics* 27, no. 1 (January 1, 2022): 186–219. https://doi.org/10.1177/1940161220964767.

Perrin, Andrew, and Monica Anderson. 2019. "Share of U.S. adults using social media, including Facebook, is mostly unchanged since 2018." *Pew Research Center,* https://www.pewresearch.org/fact-tank/2019/04/10/share-of-u-s-adults-using-social-media-including-facebook-is-mostly-unchanged-since-2018/.

Pierre, Joseph M. 2020. "Mistrust and misinformation: A two-component, socio-epistemic model of belief in conspiracy theories." *Journal of Social and Political Psychology* 8, no. 2 (October 12, 2020): 617–41. https://doi.org/10.5964/jspp.v8i2.1362.

Rathje, Steve, Jay J. Van Bavel, and Sander van der Linden. 2021. "Out-group animosity drives engagement on social media." *Proceedings of the National Academy of Sciences* 118, no. 26 (June 29, 2021): e2024292118. https://doi.org/10.1073/pnas.2024292118.

Richey, Sean. 2017. "A Birther and a Truther: The Influence of the Authoritarian Personality on Conspiracy Beliefs." *Politics & Policy* 45, no. 3 (June): 465–85. https://doi.org/10.1111/polp.12206.

Seabold, Skipper, and Josef Perktold. 2010. "statsmodels: Econometric and statistical modeling with python." In *9th Python in Science Conference.*

Search.gov. 2019. *Government-Managed Domains Outside the .Gov and .Mil Top Level Domains.* https://search.gov/developer/govt-urls.html.

Shearer, Christine, Mick West, Ken Caldeira, and Steven J. Davis. 2016. "Quantifying expert consensus against the existence of a secret, large-scale atmospheric spraying program." *Environmental Research Letters* 11, no. 8 (August): 084011. https://doi.org/10.1088/1748-9326/11/8/084011.

Sonderegger, Evan. 2015. *dotmil-domains.* https://github.com/esonderegger/dotmil-domains.

Starbird, Kate. 2017. "Examining the Alternative Media Ecosystem Through the Production of Alternative Narratives of Mass Shooting Events on Twitter." In *Proceedings of the International AAAI Conference on Web and Social Media,* 230–39. May 3, 2017. https://doi.org/10.1609/icwsm.v11i1.14878.

Sullivan, John L. 2019. "The Platforms of Podcasting: Past and Present." *Social Media + Society* 5, no. 4 (October 1, 2019): 2056305119880002. https://doi.org/10.1177/2056305119880002.

The Virality Project. 2022. *Memes, Magnets and Microchips: Narrative dynamics around COVID-19 vaccines.* Technical report. Stanford Digital Repository. https://purl.stanford.edu/mx395xj8490.

Tingley, Dustin, and Gernot Wagner. 2017. "Solar geoengineering and the chemtrails conspiracy on social media." *Palgrave Communications* 3, no. 1 (October 31, 2017): 1–7. https://doi.org/10.1057/s41599-017-0014-3.

Watts, Duncan J., David M. Rothschild, and Markus Mobius. 2021. "Measuring the news and its impact on democracy." *Proceedings of the National Academy of Sciences* 118, no. 15 (April 13, 2021). https://doi.org/10.1073/pnas.1912443118.

Wikipedia. 2021. ".gov." *Wikipedia* (May 27, 2021). https://en.wikipedia.org/w/index.php?title=.gov&oldid=1025358122.

Yang, Tian, Sílvia Majó-Vázquez, Rasmus K. Nielsen, and Sandra González-Bailón. 2020. "Exposure to news grows less fragmented with an increase in mobile access." *Proceedings of the National Academy of Sciences* 117, no. 46 (November 17, 2020): 28678–83. https://doi.org/10.1073/pnas.2006089117.

Zeng, Jing, and Mike S. Schäfer. 2021. "Conceptualizing 'Dark Platforms'. Covid-19-Related Conspiracy Theories on 8kun and Gab." *Digital Journalism* 9, no. 9 (October 21, 2021): 1321–43. https://doi.org/10.1080/21670811.2021.1938165.

Zimdars, Melissa, Megan E. Cullinan, and Kilhoe Na. 2023. "Alternative health groups on social media, misinformation, and the (de)stabilization of ontological security." *New Media & Society* (January 12, 2023): 14614448221146171. https://doi.org/10.1177/14614448221146171.

Zuckerman, Ethan. 2019. "QAnon and the Emergence of the Unreal." *Journal of Design and Science,* no. 6 (July 15, 2019). https://doi.org/10.21428/7808da6b.6b8a82b9.

Authors

Soojong Kim (sjokim@ucdavis.edu) is an Assistant Professor at the Department of Communication at the University of California Davis.

Kwanho Kim Kim is a Postdoctoral Associate at the Department of Communication at Cornell University.

Haoning Xue is a doctoral candidate at the Department of Communication at the University of California Davis.

Data availability statement

The anonymized dataset for replicating the statistical analysis in this research is available at https://osf.io/yk8dm.

Funding statement

This research received no specific grant from any funding agency.

Ethical standards

The study was reviewed and deemed exempt by the University of California Davis IRB as part of 2031428-1.

Keywords

Information ecosystem, digital infrastructure, misinformation, conspiracy theory, social media