ABSTRACT

Objectives To describe COVID-19 vaccine misinformation and track trends over time in traditional news media.


Setting English-language articles from 100 news outlets with the greatest reach.

Main outcome measures Numbers and percentages of articles containing COVID-19 vaccine misinformation over the study period. Further analysis by misinformation themes and whether articles included primary misinformation, fact-checking or simply referred to misinformation.

Results 41718 (3.2% of all COVID-19 vaccine articles) contained at least one of the vaccine misinformation themes based on the Boolean string developed for this study. The volume of such articles increased beginning in November 2020, but their percentage of all articles remained essentially stable after October 2020. 56.2% contained at least one mention of a safety theme, followed by development, production, and distribution (26.6%), and conspiracies (15.1%). Of 500 articles through January 2021 randomly selected from those identified by the Boolean string, 223 were not relevant, and 277 included either fact-checking (175 articles), refers to misinformation (87 articles) or primary misinformation (15 articles).

In eight study weeks, the reach of these 277 articles (defined as visitors to the sites containing the articles) exceeded 250 million people. Fact-checking accounted for 69.6% of all reach for these articles and the number of such articles increased after November 2020. Overall, approximately 0.1% (95% CI 0.05% to 0.16%) of all articles on COVID-19 vaccines in our sample contained primary misinformation.

Conclusions COVID-19 vaccine misinformation in traditional news media is uncommon but has the capacity to reach large numbers of readers and affect the vaccine conversation. Recent increases in fact-checking may counteract some of the misinformation currently circulating.

INTRODUCTION

Vaccines are among the most successful medical interventions, with immunisation estimated by WHO to prevent 4–5 million deaths per year.1 Antivaccine sentiment is as old as vaccines themselves, and a resurgence in false beliefs about vaccines has been a substantial and worrying aspect of the COVID-19 pandemic,2 particularly in certain developed countries.

Even before the declaration of the COVID-19 pandemic in March 2020, the WHO had identified vaccine hesitancy as one of the top 10 threats to global health.3 Surveys among adults in the USA and Canada have found likely COVID-19 vaccine refusal rates of 20%–25%, high enough to threaten the achievement of herd immunity.4 Conspiratorial beliefs related to COVID-19 vaccines can be common. One study of several Arab countries found that 28% of those surveyed expressed a belief that vaccines are intended to inject microchips into recipients, while 23% believed vaccines could cause infertility.5 Belief in conspiracy theories about COVID-19 and vaccinations is also associated with resistance to disease control measures such as mask-wearing and lockdowns, and reduced willingness to be vaccinated.6

Experimental research has shown higher refusal rates for COVID-19 vaccines among people exposed to recent misinformation about them.7 And misinformation is highly prevalent. The Center for Countering Digital Hate investigated 409 English-language anti-vaccination social media accounts and found that together they had 58 million followers.8
Misinformation has also circulated about specific classes of COVID-19 vaccines, such as the false claim that mRNA platform vaccines might genetically modify the recipient’s cells. Vaccine misinformation is also sometimes promoted on social media by malign state actors with an interest in undermining liberal democracies.

We are not aware of any published work that exclusively quantifies the extent of vaccine misinformation in traditional news media in the context of the COVID-19 pandemic. Traditional news media can have greater readership and potentially more influence on public attitudes than social media because of the perception that they are more authoritative; moreover social media postings frequently link to traditional news media sources. Accordingly, this study aims to describe COVID-19 vaccine misinformation and track trends over time in English-language traditional news media, referred to as traditional media moving forward.

METHODS

To examine the magnitude of vaccine misinformation in traditional media (Professionally Generated Content, not User Generated Content), we used Cision’s NextGen Communications Cloud platform for the period 27 July 2020 (the day that phase 3 trials for the Moderna and Pfizer vaccines began) through 30 June 2021. The NextGen platform is a commercial platform that aggregates online content (including licensed print and traditional media articles via LexisNexis), news-themed blogs, podcasts, television and radio, sourced via webcrawlers and third-party content providers. In total, excluding social media sources, it encompasses a network of over 7 million global sources of print, broadcast and online content. The database aggregates global coverage, with the largest volume of English-content. Articles were also assigned in a non-exclusive fashion to misinformation themes and all tracked themes in the primary text. Articles were characterised as either (1) primary misinformation (ie, articles promoting misinformation); (2) fact-checking (ie, articles concerned with determining whether certain assertions were accurate) or (3) refers to misinformation (ie, made reference to misinformation but did not advance it or referenced the COVID-19 vaccine ‘infodemic’ without providing specific fact-checking). Definitions of these terms and example articles are found in online supplemental material 3. Articles were also assigned in a non-mutually exclusive fashion to misinformation themes and subthemes, including designation to a ‘general’ subtheme when elements of the article were specific enough to be included in the parent theme but not specific enough to be included in a subtheme. The coders met with one of the authors (JA) who helped resolve any disagreements and refine coding practices based on the coding rubric.
The remaining 300 articles were then coded by one of the two original coders.

We used descriptive statistics to describe the number of articles from the full sample that contained each of the themes and subthemes as well as their trends over time. We carried out qualitative assessments of articles published at the time of peaks in reach and described what the outlets studied were publishing during those times. For the 500-sample subset, we used similar techniques to describe numbers and trends for the three categories of misinformation and selected themes. We also described the reach of the randomly selected vaccine misinformation articles, including their trends over time.

To calculate the 95% CIs surrounding the percentage of the random subset containing primary misinformation, we used the Clopper and Pearson method.15

**Patient and public involvement statement**

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research. This study does not involve human participants.

**RESULTS**

Of the 1 298 054 COVID-19 vaccine articles that appeared between 27 July 2020 and 30 June 2021 in the 100 outlets with the greatest reach, 41 718 (3.2%) contained at least one of the vaccination misinformation themes based on our Boolean string (table 1 and figure 1). In total, 23 448 articles (56.2%) contained at least one mention of a safety theme, followed by development, production and distribution (hereinafter ‘development’); 11 114 articles or 26.6%, conspiracies (6289 articles or 15.1%), morality and ethics (1806 articles or 4.3%), political and financial (1731 articles or 4.1%) and alternative treatments (771 articles or 1.8%). Figure 2 provides the numbers of articles by subtheme. The most common subthemes were general side effects (9693 articles or 23.2%) and developed too quickly (5565 articles or 13.3%), followed by cause COVID-19, not tested properly and chemicals (all with about 3500 articles or 8.3%). Articles referring to election conspiracies, mandates causes autism and natural immunity all had fewer than 300 mentions. The USA was the country of origin for 60% of these articles, followed by the UK (9%), Canada (7%), India (5%) and Australia (4%).

The volume of vaccine articles was essentially stable from July through early November, after which there was an approximately threefold increase in the number of articles, with a slight decline after March (figure 3A). The number of articles containing misinformation peaked in
February (figure 3B). However, viewed as a percentage of all vaccine articles, misinformation-containing articles were a higher percentage from July to mid-October 2020, always exceeding 4% and ranging as high as 8.7%, and have been generally stable at 3% since then (figure 3C).

Trends in the misinformation themes are depicted in figure 4A. The safety theme increased dramatically in November and December (driven by the filing of emergency use authorisations with regulatory agencies) and has remained higher than all other categories ever since, with another peak in early March related to blood clots associated with the AstraZeneca vaccine. Other notable peaks occurred in August–September in development (related to anti-vaccine protests and comments by the US President) and in conspiracy in January–February associated with a pharmacist in Wisconsin, USA who intentionally destroyed COVID-19 vaccines.16

Of the 500 articles identified as related to vaccine misinformation by our Boolean string and randomly selected for coder review, 158 (31.6%) were determined to be unrelated to vaccine misinformation (often due to sidebar advertisements or links to other articles) and 65 (13.0%) were unavailable for inspection due to dead links or paywalls.

This left 277 articles (55.4%) that contained at least one misinformation theme. In this latter subset, the most common theme was development (151 articles or 54.5%), followed by safety (124 articles or 44.8%) and conspiracy (67 articles or 24.2%), with the remaining three themes all under 20% (table 2). One hundred and forty-four articles (52.0%) contained more than one theme, most commonly development combined with safety (47.2% of all articles with more than one theme).
Of these 277 articles, the majority (175 articles or 63.2%) were considered fact-checking, followed by refers to misinformation (87 articles or 31.4%), and primary misinformation (15 articles or 5.4%; table 2). This latter category included an article in which a US Senator asserts that China was seeking to ‘hijack or disrupt’ COVID-19 vaccine development\(^\text{17}\) and another from Australia in which it is asserted that the advent of vaccines will lead to


Based on 1 298 054 articles in 100 outlets with greatest reach that discussed COVID-19 vaccines.

an influx of immigrants. The breakdown of these three categories of misinformation was generally similar across the six themes, except political and financial had somewhat more primary misinformation (6 of 47 articles or 12.8%) than other themes.

The most common themes with at least one mention in the 15 primary misinformation articles were development (nine articles), followed by safety and political and financial (six articles each). Seven primary misinformation articles had more than one theme and two had more than three. For both development and safety, the general subtheme contained over half the articles. The three categories of misinformation were generally stable over time, with a notable increase in fact-checking (mostly development and safety) beginning in November (figure 4B).

Overall, of 1298054 articles on COVID-19 vaccines, 3.2% contained apparent misinformation according to our search string and 15 articles in our random subset of 500 (3.0%; 95% CI 1.7% to 4.9%) contained primary misinformation. Thus, one can estimate that 0.096% of all COVID-19 vaccine articles (3.2%*3.0%; 95% CI 0.05% to 0.16%) contained primary misinformation. If we remove the 65 articles that were unavailable or behind paywalls, we estimate that 0.11% of all COVID-19 vaccine articles contained primary misinformation (95% CI 0.06% to 0.18%).

Table 2  Summary of COVID-19 vaccine misinformation findings

<table>
<thead>
<tr>
<th>Source data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Articles on COVID-19 vaccines</td>
<td>27 122 380</td>
</tr>
<tr>
<td>Articles on COVID-19 from 100 outlets with greatest reach</td>
<td>1 298 054 (4.8%)</td>
</tr>
<tr>
<td>Articles containing misinformation from 100 outlets with greatest reach</td>
<td>41 718 (3.2%)</td>
</tr>
<tr>
<td>Close-read articles with misinformation</td>
<td>277/500 (55.4%)</td>
</tr>
</tbody>
</table>

Themes in misinformation conversation (N=41 718)

<table>
<thead>
<tr>
<th>Theme</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>23 448 (56.2%)</td>
</tr>
<tr>
<td>Development, production and distribution</td>
<td>11 114 (26.6%)</td>
</tr>
<tr>
<td>Conspiracies</td>
<td>6 289 (15.1%)</td>
</tr>
<tr>
<td>Morality and ethics</td>
<td>1 806 (4.3%)</td>
</tr>
<tr>
<td>Political and financial</td>
<td>1 731 (4.1%)</td>
</tr>
<tr>
<td>Alternative treatments</td>
<td>771 (1.8%)</td>
</tr>
</tbody>
</table>

Themes in close-read subset (N=277)

<table>
<thead>
<tr>
<th>Theme</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Development, production, distribution</td>
<td>151 (54.5%)</td>
</tr>
<tr>
<td>Safety</td>
<td>124 (44.8%)</td>
</tr>
<tr>
<td>Conspiracies</td>
<td>67 (24.2%)</td>
</tr>
<tr>
<td>Political and financial</td>
<td>47 (17.0%)</td>
</tr>
<tr>
<td>Alternative treatments</td>
<td>19 (6.9%)</td>
</tr>
<tr>
<td>Morality and ethics</td>
<td>18 (6.5%)</td>
</tr>
</tbody>
</table>

Categories in close-read subset (N=277)

<table>
<thead>
<tr>
<th>Category</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fact-checking</td>
<td>175 (63.2%)</td>
</tr>
<tr>
<td>Refers to misinformation</td>
<td>87 (31.4%)</td>
</tr>
<tr>
<td>Primary misinformation</td>
<td>15 (5.4%)</td>
</tr>
</tbody>
</table>

Figure 4C depicts the reach of the 277 articles in our random subset. Peaks of approximately 300–450 million unique visitors to the outlets’ websites per week for safety and development were identified in August (driven by several articles on Russian vaccine development on CNN) and September, with additional peaks of almost 350 million for each in the November–December period. These included articles on Bell’s Palsy, US Food and Drug Administration Advisory Committee meetings, and others featuring prominent US Catholic Bishops urging their congregations to avoid the Johnson&Johnson vaccine, claiming it contained fetal components or fetal-derived components. There was also an increase in the conspiracy category to 237 million in the week beginning 11 January, driven by fact-checking regarding claims that the Rockefeller Foundation had planned the COVID-19 pandemic in ‘Operation Lockstep’. Together, articles that had at least one mention of development had 54.8% of all reach in the 277 articles in the study period, while those with safety mentions had 49.6% of all reach occurring in articles mentioning at least one of these.

Figure 4D examines the reach of these same articles by categories of misinformation, demonstrating that the peaks were largely driven by fact-checking, which accounted for 69.6% of all reach in the study period.
Primary misinformation represented 5.5% of all reach, similar to its percentage of articles. The percentage of reach that was related to primary misinformation was higher in the UK (15.6%) than in the USA (8.9%), but the reach of such articles from the USA was larger (346 million vs 68 million).

Overall, in the first half of the study, articles from the USA had 80.8% of reach, compared with 10.8% from the UK, and 2.8% from India. These percentages were generally consistent across themes, except the United Kingdom had a higher share of conspiracy reach (20.2%) and a lower share of alternatives reach (0.2%).

**DISCUSSION**

Our analysis used a large international database of online traditional media to assess English-language articles on COVID-19 vaccines, allowing us to track trends in misinformation, and particular types of misinformation, as the pandemic unfolded. Of 1298054 articles on COVID-19 vaccines in the 100 news-focused outlets with the greatest reach during the study period, approximately 0.1% contained primary misinformation.

However, even these articles had the potential to have substantial reach. In eight particular weeks during the first 6 months of our study, articles among the 277 we identified in our subset analysis as containing misinformation in some form appeared on websites visited by over a quarter of a billion readers. This information has the potential to affect the vaccine conversation and contribute to vaccine hesitancy, particularly if shared avidly among certain groups. Even articles that simply refer to misinformation (31% of the misinformation articles in our close-read subset), but do not refute it, have the potential to influence the conversation, a phenomenon known as the ‘illusory truth effect’. Moreover, articles in news outlets with less reach than those included in our study may have a significant impact on the vaccine conversation in local communities.

The main themes of the articles with misinformation in our close-read subset were development (55% of both articles and reach) and safety (45% of articles and 50% of reach), suggesting that, at least in these more influential outlets, the primary focus was on the process of product approval, as opposed to conspiracy theories, moral/ethical concerns, or alternative therapies. In an encouraging sign, fact-checking stripped refers to misinformation and primary misinformation articles in most weeks, particularly from November onward, suggesting that traditional media are responding to public concern about misinformation.

A previous study of traditional media by some of the present authors examined all COVID-19-related misinformation and found 1.1 million news articles that disseminated, amplified or reported on misinformation related to the pandemic between 1 January 2020 and 26 May 2020. Much of the misinformation originated with powerful actors, including then-US President Trump, who was the largest driver of the COVID-19 misinformation. This study extends that work by including a close reading of a random subset of identified articles.

A study conducted in the early phases of the pandemic found that both mainstream broadcast and print and online media use correlated with accurate beliefs about the nature and lethality of COVID-19, while use of conservative media correlated with conspiracy theories about the pandemic. A later study collected hundreds of rumours and conspiracies related to COVID-19 vaccines in traditional and social media but did not estimate the prevalence of misinformation.

Evidence of the adverse effects of traditional media stories on vaccination rates existed well before COVID-19. In Japan, for example, a dramatic fall in HPV vaccination rates—from 80% in 2013 to less than 1% more recently for girls aged 12–16 years—followed extensive mainstream media coverage of anecdotal ‘vaccine injury’ events. In Denmark, the nationwide airing of a controversial television documentary entitled ‘The Vaccinated Girls–Sick and Abandoned’ similarly led to a sharp decline in the uptake of HPV vaccine.

This study is subject to a number of limitations. First, the size of the database required an automated approach to data analysis, which can lead to imprecision in the estimates generated. However, we also undertook a closer inspection of a random subset of articles identified by the automated approach. This identified a fairly high false-positive rate for our Boolean string, but a separate analysis revealed that its false-negative rate was low. Resource constraints prevented us from closely examining more than 500 articles. The close-read subset was confined to the first part of the study period, although we have no specific reason to think that the false-positive rate would be different in the second part of the study period. Some assurance of generalisability is provided by the generally stable number of articles with each misinformation theme in the full dataset in the first part of the study compared with the second, except for an increase in the safety theme following authorisation of the initial vaccines (figure 4A) and the lack of change in the percentage of all vaccine articles containing misinformation after October 2020 (figure 3C). Second, the close readings are by their nature subjective, although we used multiple coders for a substantial subset of these and used a standardised rubric for all. Third, we cannot generalise our findings beyond the top 100 outlets or to non-English-language sources. Fourth, outlet reach, although a standard measure in media analysis, is based on visitors to particular sites from desktop computers in a given month and excludes mobile device use. While there is no assurance that visitors actually read the articles in question, trends over time are likely still meaningful. Finally, the rarity of primary misinformation in the closely read subset precluded our conducting various cross-tabulations that may have been of interest, including primary misinformation rates by outlet and country, and limit the conclusions that can be drawn from this study.
Policy implications
Public attitudes to COVID-19 vaccines are not static and are responsive to current information and sentiment trends around the vaccines. In the UK, vaccine hesitancy dropped from 39% in mid-November 2020 to 11% in mid-April 2021 as the country’s vaccination programme advanced, according to YouGov public opinion polling.25

Given the predominance of the safety and development themes, better collaboration between media outlets and the public health/scientific communities might help ensure that journalists reporting on vaccines understand—and can accurately communicate—the rigorous scientific procedures by which vaccines are developed and tested for safety. Clinicians should be aware of the most prevalent forms of misinformation and be ready to address them in a direct and respectful manner and respected community leaders should be enlisted to counter misinformation.

To mitigate the danger of uncredentialed experts promoting misinformation on COVID-19 vaccines, media outlets could work with public health organisations to generate an inclusive list of vetted science communicators and genuine public health experts who could serve as sources and/or review vaccine-related content to ensure that it is scientifically and medically accurate. The American Association for the Advancement of Science has such a service, called SciLine.26 The WHO’s Vaccine Safety Net also certifies websites that provide reliable information on vaccine safety.27

Similarly, government agencies could conduct trainings for science and medical reporters to improve their understanding about how vaccines are developed, reviewed, and regulated and should address misinformation directly in public education campaigns and through collaborations with community-based organisations and trusted voices within communities. To their credit, governments and other organisations have been trying to do more to meet this need. The US Surgeon General’s report on misinformation provides a model for drawing public attention to this critical issue.28 Governments have held media briefings and health education campaigns, and there has been a proliferation of private sector initiatives such as the US-based Made to Save29 programme and the Mercury Project,30 and the UK-based Vaccine Confidence Project.31

However, more may need to be done to address the effects of misinformation as the pandemic evolves and vaccine development presents new questions, especially in areas where vaccination uptake has slowed.

Media outlets should also be made aware of the various conspiracy theories circulating around vaccines, including the major actors involved in their dissemination, to help them avoid inadvertently sharing misinformation. Media might directly address the various reasons behind vaccine hesitancy in their reports. Reporters should also challenge misinformation shared by public figures and refrain from including misleading quotes in their coverage without context or fact-checking, preferably in the same report.

CONCLUSION
COVID-19 vaccine misinformation in traditional media is uncommon but has the capacity to reach large numbers of readers and affect the vaccine conversation. Recent increases in fact-checking may counteract some of the misinformation currently circulating.

Contributors PL led study design and write-up and is the overall guarantor for this article. JA conducted the statistical analysis of the NextGen dataset. They also led the design and analysis of the close-read subset. ML assisted in study design and write-up. KS oversaw statistical analysis of the NextGen dataset. RCC assisted in the design of the close-read subset and identification of appropriate keywords for the NextGen analysis. AP assisted in the analysis of the close-read subset. SDE provided overall study direction and administrative oversight. All authors reviewed, edited and approved the final manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests The Center for Science in the Public Interest accepts no donations from government or industry. Cision is a company that performs media analysis and provides other communication services for paying clients across a variety of sectors, including the Bill & Melinda Gates Foundation. This study may not reflect the views or attitudes of Cision or Cision’s clients. The Alliance for Science is funded in part by the Bill & Melinda Gates Foundation, although it did not contribute funding for this study. A list of other donors can be found at https://allianceforscience.cornell.edu/about/funders/. Every Child By Two (doing business as Vaccinate Your Family) accepts support from individuals, philanthropic entities, the makers of vaccines and government agencies. ECBT’s funding policy can be found on its website https://vaccinateyourfamily.org.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Data that support all figures and numerical assertions can be shared.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

ORCID iD
Peter Lurie http://orcid.org/0000-0001-7867-4951

REFERENCES


(f"COVID-19" OR coronavirus OR COVID OR "sars-cov-2" OR "Severe acute respiratory syndrome coronavirus" OR "beta-coronavirus") AND (vaccine OR vaccines OR vaccinations OR vaccination OR vaccines OR vaccination OR vaccine OR immunization OR vaccination or immunisation or immunized).


