

Facebook Pages, the “Disneyland” Measles Outbreak, and Promotion of Vaccine Refusal as a Civil Right, 2009–2019

David A. Broniatowski, PhD, Amelia M. Jamison, MAA, MPH, Neil F. Johnson, PhD, Nicolás Velasquez, PhD, Rhys Leahy, BA, Nicholas Johnson Restrepo, BSc, Mark Dredze, PhD, and Sandra C. Quinn, PhD

Objectives. To understand changes in how Facebook pages frame vaccine opposition.

Methods. We categorized 204 Facebook pages expressing vaccine opposition, extracting public posts through November 20, 2019. We analyzed posts from October 2009 through October 2019 to examine if pages' content was coalescing.

Results. Activity in pages promoting vaccine choice as a civil liberty increased in January 2015, April 2016, and January 2019 ($t[76]=11.33$ [$P<.001$]; $t[46]=7.88$ [$P<.001$]; and $t[41]=17.27$ [$P<.001$], respectively). The 2019 increase was strongest in pages mentioning US states ($t[41]=19.06$; $P<.001$). Discussion about vaccine safety decreased ($r_s[119]=-0.61$; $P<.001$) while discussion about civil liberties increased ($r_s[119]=0.33$; $P<.001$). Page categories increasingly resembled one another (civil liberties: $r_s[119]=-0.50$ [$P<.001$]; alternative medicine: $r_s[84]=-0.77$ [$P<.001$]; conspiracy theories: $r_s[119]=-0.46$ [$P<.001$]; morality: $r_s[106]=-0.65$ [$P<.001$]; safety and efficacy: $r_s[119]=-0.46$ [$P<.001$]).

Conclusions. The “Disneyland” measles outbreak drew vaccine opposition into the political mainstream, followed by promotional campaigns conducted in pages framing vaccine refusal as a civil right. Political mobilization in state-focused pages followed in 2019.

Public Health Implications. Policymakers should expect increasing attempts to alter state legislation associated with vaccine exemptions, potentially accompanied by fiercer lobbying from specific celebrities. (*Am J Public Health.* 2020;110:S312–S318. <https://doi.org/10.2105/AJPH.2020.305869>)

 See also Chou and Gaysynsky, p. S270.

Facebook connects billions of people globally,¹ enabling individuals to share information on pages organized around common interests. Facebook can therefore be used to spread health-related information² and misinformation^{3–5} quickly and widely, affecting public discourse^{6,7} and potentially driving real-world behaviors. These community dynamics could also allow malicious actors to mobilize vulnerable communities for their own purposes.⁸ For example, Facebook has been linked to recent outbreaks of violence around the world.⁹

The dynamics of health misinformation on Facebook pose a threat to vaccination programs. Social media exposure is theorized to amplify vaccine skepticism,¹⁰ exposing billions of users to misinformation about vaccines, increasing hesitancy and delay,^{11–13} eroding trust in health care

providers and public health experts,^{12,14} and reducing vaccination rates, with repeated exposures potentially exacerbating this hesitancy.¹⁵

In addition to amplifying misinformation, the group structure of social media platforms may concentrate it,⁷ polarizing

communities.⁶ Tightly knit communities that collectively refuse to vaccinate lack herd immunity—meaning that a small number of disease exposures can lead to deadly outbreaks—and damage herd immunity for the broader population. In 2019, the US Centers for Disease Control and Prevention reported outbreaks of measles in several US states and worldwide, all of which struck communities with low vaccination rates (<https://www.cdc.gov/measles/cases-outbreaks.html>). Finally, some have raised concerns that the COVID-19 “infodemic” could trigger vaccine refusal.¹⁶ Public health communicators must therefore attend to rationales for vaccine refusal and how this misinformation might affect real-world behaviors.

Rationales for vaccine refusal vary widely and often contradict one another.¹⁷ One emphasizes vaccine harms, health risks, or safety concerns associated with vaccination. Another frames vaccination as a civil liberties issue, asserting parental rights to determine medical care. Others embrace conspiracy theories (emphasizing scientific, governmental, and pharmaceutical malfeasance) or alternatives to Western medicine such as naturopathic cures or dietary supplements. Historically, these different rationales have been associated with different social groups.¹⁸

ABOUT THE AUTHORS

David A. Broniatowski is with the Department of Engineering Management and Systems Engineering, School of Engineering and Applied Science, and the Institute for Data, Democracy, and Politics, The George Washington University, Washington, DC. Amelia M. Jamison is with the Maryland Center for Health Equity, School of Public Health, University of Maryland, College Park. Neil F. Johnson is with the Institute for Data, Democracy, and Politics, and the Department of Physics, and the Corcoran College of Arts and Sciences, The George Washington University. Nicolás Velasquez, Rhys Leahy, and Nicholas Johnson Restrepo are with the Institute for Data, Democracy, and Politics, The George Washington University. Mark Dredze is with the Department of Computer Science, Whiting School of Engineering, Johns Hopkins University, Baltimore, MD. Sandra C. Quinn is with the Maryland Center for Health Equity, School of Public Health, and the Department of Family Science, School of Public Health, University of Maryland.

Correspondence should be sent to David A. Broniatowski, 800 22nd St NW #2700, Washington, DC 20052 (e-mail: broniatowski@gwu.edu). Reprints can be ordered at <http://www.ajph.org> by clicking the “Reprints” link.

This article was accepted July 1, 2020.

<https://doi.org/10.2105/AJPH.2020.305869>

On the surface, social media seem to reflect this community structure, with specific Facebook pages corresponding to these audiences.

On the other hand, recent outbreaks and legislative proposals around the world¹⁹ suggest that vaccine opposition may be coalescing around a common narrative, emphasizing civil rights and freedom from elitist government overreach. Because coalescence could facilitate organized political action around vaccine opposition, we sought to test this hypothesis, examining how the discourse of vaccine opponents on social media has changed over time.

Here, we report the results of a retrospective observational study characterizing the content of 204 public Facebook pages, emphasizing different vaccine opponent narratives. Using a set of 284 266 posts from October 2009 through October 2019, we quantified changes in the popularity of these narratives. Finally, we examined the proportion of messages associated with different communities, testing the hypothesis that pages expressing a specific group affiliation nevertheless post vaccine refusal content from a wide range of different perspectives.

METHODS

We conducted 3 analyses. First, we categorized Facebook pages opposing vaccination and measured the volume of posts in each category. Second, we described the topics of discourse within each page type over time and tested the hypothesis that pages in each category preferentially shared posts reflecting an underlying group identity. Third, we measured whether content across page types was coalescing over time.

Data Collection

Using a method initially developed for identifying online community structure,²⁰ we identified a cluster of Facebook pages expressing vaccine opposition. We first identified a seed set of pages promoting content opposing vaccination, then added additional pages if they “liked” these seed pages and vice versa. This expanded list was then cross-checked to eliminate false identifications, and we iterated this process by using

snowball sampling^{20–22} until no more pages were added. We identified 303 Facebook pages pertaining to vaccines, sampled on March 25, 2019. Using data from Crowd-Tangle,²³ a public insights tool owned and operated by Facebook, we downloaded all public posts for these pages on November 21, 2019. After removing 22 (7%) non-English pages, 214 (71%) of the remaining pages, involving 1 414 081 “fans” as of March 25, 2019, expressed vaccine opposition. We successfully downloaded all 288 175 posts from 204 of these pages (95%; we were unable to download posts for some pages, and 1 page, with 3 511 posts, was excluded because of a coding error), with a total of 1 397 086 (99%) fans.

Analysis

Which online communities are most active? Using information contained in pages’ title and “about” sections, we categorized pages into 5 high-level non-mutually exclusive content categories derived from Kata’s²⁴ typology of vaccine-opposing content: (1) safety and efficacy, (2) alternative medicine, (3) civil liberties, (4) conspiracy theories, and (5) morality. We did not use the sixth category, misinformation, because misinformation appeared across all pages. Two independent annotators (A. M. J. and E. S.) agreed in 76.7% of instances (Cohen’s $\kappa = 0.66$; 95% confidence interval [CI] = 0.58, 0.74, indicating “substantial” agreement).²⁵ Discrepancies were reconciled discursively and final codes reflect consensus. We also identified pages containing the name of a US state (e.g., “Michigan for Vaccine Choice”). We then enumerated fans and monthly post volume for each page category.

Raw post counts (Appendix A, Figure A, available as a supplement to the online version of this article at <http://www.ajph.org>) suggest qualitative changes in activity surrounding (1) January 2015: the “Disneyland” measles outbreak²⁶; (2) April 2016: the release of *Vaxxed*, a film directed by a discredited former physician; and (3) January 2019: a US measles epidemic. We used the *t* test to examine changes in post frequency in different page categories before and after these events (see Appendix A, Figures B and C, for additional evidence for these specific events).

What content is most likely to be posted in these pages? We combined the message text and, if applicable, link text, and link description into a single document for each post after removing all URLs. Using the MALLET software package (AK McCallum, Amherst, MA) with Bayesian hyperparameter optimization,²⁷ we inferred 100 topics for these documents using a Latent Dirichlet Allocation²⁸ model fit to all 288 175 posts through November 20, 2019. Two authors (D. A. B. and A. M. J.) independently matched each of the resulting topics to 1 of 6 content or 2 design (“emotive appeals” or “content aspects”) attributes listed in Kata’s typology²⁴ after manually inspecting the top 10 keywords and 50 posts for each latent Dirichlet allocation topic (Cohen’s $\kappa = 0.67$; 95% CI = 0.58, 0.77). We merged the conspiracy-oriented attributes “profit,” “collusion,” “protection,” and “coverup” attributes because of overlapping content; both annotators independently reported inability to distinguish among these attributes. In addition, we added new attributes reflecting novel content: within “alternative medicine,” dieting and lifestyle; within “civil liberties,” politics, political rallies, and events; and a “miscellaneous” category with design attributes specific to social media platforms (e.g., hashtags). Disagreements between annotators were reconciled discursively and final codes reflect consensus.

Next, we averaged the document-specific probability distributions for all documents in each month to generate monthly distributions over topics for 284 266 (99%) posts from October 2009 through October 2019. (We excluded data from before October 2009 [33 posts; 0.01%] because they had fewer than 20 posts per month, making probability distribution calculations unreliable. In addition, we excluded November 2019 [3876 posts; 1%] because we only had partial data for that month.) We generated similar average monthly distributions for each page category. We examined how these category-specific distributions increased or decreased in popularity²⁹ using Spearman’s rank correlations to account for floor and ceiling effects. Finally, we segmented the data into the same 4 time periods as described previously.

Are rationales for vaccine opposition coalescing around common topics? For each page type, we calculated the average monthly proportions

of category-consistent topics compared with post proportions in all other pages (e.g., civil liberties topic proportions in civil liberties pages compared with civil liberties topics in all other pages). We tested the hypothesis that pages had higher proportions of category-consistent content. Next, we examined how these proportions changed over time. Finally, we calculated the Kullback–Leibler divergence—a standard metric of probability distribution similarity—between the category-specific monthly topic distribution for each Facebook page category and the average distribution for all posts in October 2019, the last full month in our sample. We examined whether the Kullback–Leibler divergence for each page category decreased over time, which would indicate that the distribution of posts within that page category was becoming more similar to the reference.

RESULTS

Out of 204 Facebook pages in our sample, 90 (44%) were categorized as “civil liberties,” 90 (44%) as “safety and efficacy,” 61 (30%) as “conspiracy theories,” 16 (8%) as “alternative medicine,” and 7 (3%) as “morality” (43 pages [21%] had 2 annotations; see Appendix A, Table A). A total of 53 (26%) pages contained the name of a US state in their title. After applying a logarithmic transform to correct for skewed data, we did not detect statistically significant differences in the number of fans ($F[6197] = 0.14$; $P = .99$) or posts ($F[6197] = 0.36$; $P = .90$) per page by page type (Appendix A, Figures D and E).

Measles Outbreaks, Movies, and Legislative Mandates

Figure 1 shows several statistically significant nonlinear increases in post volume in the time period between October 2009 and October 2019. Compared with previous months, overall monthly post volume increased during the period between January 2015 (the “Disneyland” measles outbreak) and March 2016 ($t[76] = 12.16$; $P < .001$). A second increase occurred in the period between April 2016 (the release of *Vaxxed*) and December 2018 ($t[46] = 3.63$; $P < .001$). This second increase seems to have occurred in pages promoting “civil liberties” ($t[46] = 9.46$;

$P < .001$) but not associated with any specific states. By contrast, post volumes in other pages decreased slightly ($t[46] = -2.93$; $P = .005$). Finally, compared with the period between April 2016 and December 2018, a statistically significant increase occurred in January 2019 (the 2019 US measles epidemic; $t[41] = 13.47$; $P < .001$). These changes cannot be attributed to linear increases in the overall Facebook user base (Appendix A, Figure F).

This increase seems to be primarily associated with activity in civil liberties pages, but also pages mentioning a US state in their title. Because there was statistically significant overlap between these categories (38 [72%] of the 53 state pages were categorized as “civil liberties”; $\chi^2[1] = 22.09$; $P < .001$), we examined them separately. Civil liberties pages mentioning states ($t[41] = 17.31$; $P < .001$), civil liberties pages not mentioning states ($t[41] = 12.85$; $P < .001$), and pages mentioning states but not civil liberties ($t[41] = 21.45$; $P < .001$) all experienced statistically significant increases in post volumes. Pages mentioning states contained a total of 67 036 (24%) posts, with 33 498 (50%) posts in pages mentioning just 6 states: Michigan, Oregon, Georgia, New Hampshire, Delaware, and Vermont (raw counts in Appendix A, Table B). Pages mentioning neither states nor civil liberties did not experience a statistically significant change in post volumes ($t[41] = -1.67$; $P = .10$).

Political Mobilization and Celebrity Spokesmen

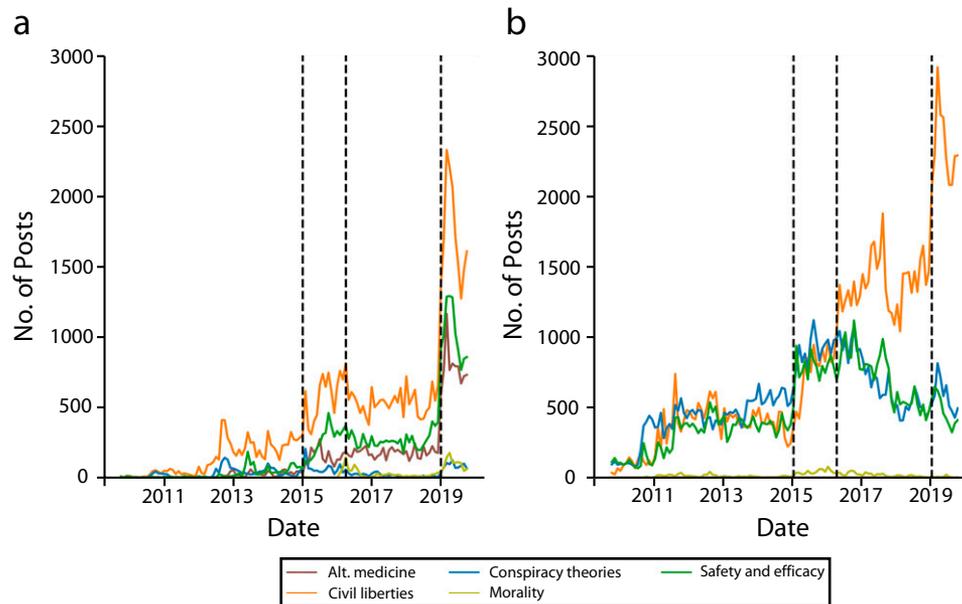
Appendix B (available as a supplement to the online version of this article at <http://www.ajph.org>) shows the proportion of all topics in our data set, aggregated into attributes and typology categories (see Appendix A, Table B, for topic descriptions). Results show that posts in our sample were roughly equally likely to be about conspiracy theories (21%), civil liberties (20%), and safety and efficacy (19%). Figure 2 shows that the monthly share of posts pertaining to safety and efficacy decreased overall ($r_s[119] = -0.61$; $P < .001$), driven by a decrease in posts about immunity to specific diseases (e.g., indicating that vaccines are ineffective, cause diseases, or otherwise weaken the immune system; $r_s[119] = -0.71$; $P < .001$). This decrease coincided with the “Disneyland” measles

outbreak ($t[76] = -4.51$; $P < .001$) and the launch of *Vaxxed* ($t[46] = 2.94$; $P = .005$). By contrast, the share of posts pertaining to civil liberties has grown overall ($r_s[119] = 0.33$; $P < .001$), with discrete increases associated with both the 2015 ($t[76] = 5.41$; $P < .001$) and 2019 ($t[41] = 6.38$; $P < .001$) measles outbreaks but a decrease in between ($t[46] = -3.20$; $P = .003$). These changes are largely attributable to posts opposing vaccine mandates (“totalitarianism”; $r_s[119] = 0.45$; $P < .001$), which follow the same pattern: increases in 2015 ($t[76] = 5.75$; $P < .001$) and 2019 ($t[41] = 5.91$; $P < .001$), with a decrease in between ($t[46] = -2.54$; $P = .01$). Furthermore, we saw discrete increases in posts advocating political mobilization (“politics”) in both 2015 ($t[76] = 3.78$; $P < .001$) and 2019 ($t[41] = 5.23$; $P < .001$), and with a statistically significant decrease in between ($t[73] = 3.52$; $P < .001$).

The share of posts reflecting “content aspects” also increased statistically significantly ($r_s[116] = 0.29$; $P = .001$), driven primarily by posts about *Vaxxed* ($r_s[119] = 0.79$; $P < .001$), with statistically significant increases corresponding to the lead-up ($t[76] = 6.17$; $P < .001$) and launch ($t[46] = 5.79$; $P < .001$) of *Vaxxed*, but with a statistically significant decrease afterward ($t[41] = -4.01$; $P < .001$). Concurrently, posts referring to the movie’s producer have steadily increased ($r_s[119] = 0.82$; $P < .001$), as have those referring to a political activist and attorney with whom he frequently collaborates ($r_s[119] = 0.73$; $P < .001$). By contrast, posts referring to a candidate for public office in New York City who opposes vaccines ($r_s[119] = -0.40$; $P < .001$) and the founder of a nonprofit who advocates for “parents of vaccine-injured children” ($r_s[119] = -0.67$; $P < .001$) have both decreased over time.

Coalescence of Rationales Across Pages

As expected, pages categorized as promoting civil liberties ($t[119] = 12.67$; $P < .001$) and conspiracies ($t[119] = 6.67$; $P < .001$) posted statistically significantly more content reflecting their corresponding topic categories than did other pages. By contrast, we did not detect statistically significant differences between pages categorized as about safety and efficacy ($t[119] = -0.50$; $P = .62$) and morality ($t[106] = -1.90$; $P = .06$) and



Note. Vertical dashed lines correspond to the “Disneyland” measles outbreak (January 2015), the launch of *Vaxxed* (April 2016), and the onset of the 2019 measles epidemic (January 2019).

FIGURE 1—Monthly Frequency of Posts in Pages, by Category of Facebook Page, That (a) Do and (b) Do Not Contain a US State Name in the Title: October 2009–October 2019

their corresponding categories. Pages pertaining to alternative medicine had statistically significantly less alternative medicine content than did other pages ($t[84] = -8.90$; $P < .001$).

All page types displayed an overall decreasing trend in the Kullback–Leibler divergence between each month’s topic probability distribution and the average distribution for October 2019 (civil liberties: $r_s[119] = -0.50$ [$P < .001$]; alternative medicine: $r_s[84] = -0.77$ [$P < .001$]; conspiracy theories: $r_s[119] = -0.46$ [$P < .001$]; morality: $r_s[106] = -0.65$ [$P < .001$]; safety and efficacy: $r_s[119] = -0.46$ [$P < .001$]). Thus, each Facebook page category is hosting increasingly similar content. For example, pages pertaining to safety concerns contained equal proportions of posts about safety concerns as those that did not pertain to safety concerns (Figure 3). Even pages pertaining to conspiracy theories, which seem to have experienced a relative increase starting in 2017, are converging.

DISCUSSION

Our results demonstrate how the vaccine opponent discourse has increased in volume and evolved over time, with 3 distinct phases:

1. vaccine opposition becomes mainstream,
2. popular media spokesmen target civil liberties pages, and
3. civil liberties pages promote state-level political mobilization.

Phase 1

The “Disneyland” measles outbreak brought national attention to mainstream vaccine opposition. Before this date, measles outbreaks in the United States had garnered comparatively little media attention. This outbreak sparked a national debate and the enactment of legislation to curb personal belief exemptions in California. During this period, the volume of posts on all vaccine opponent pages increased, and civil liberties discourse, in particular, became widespread.

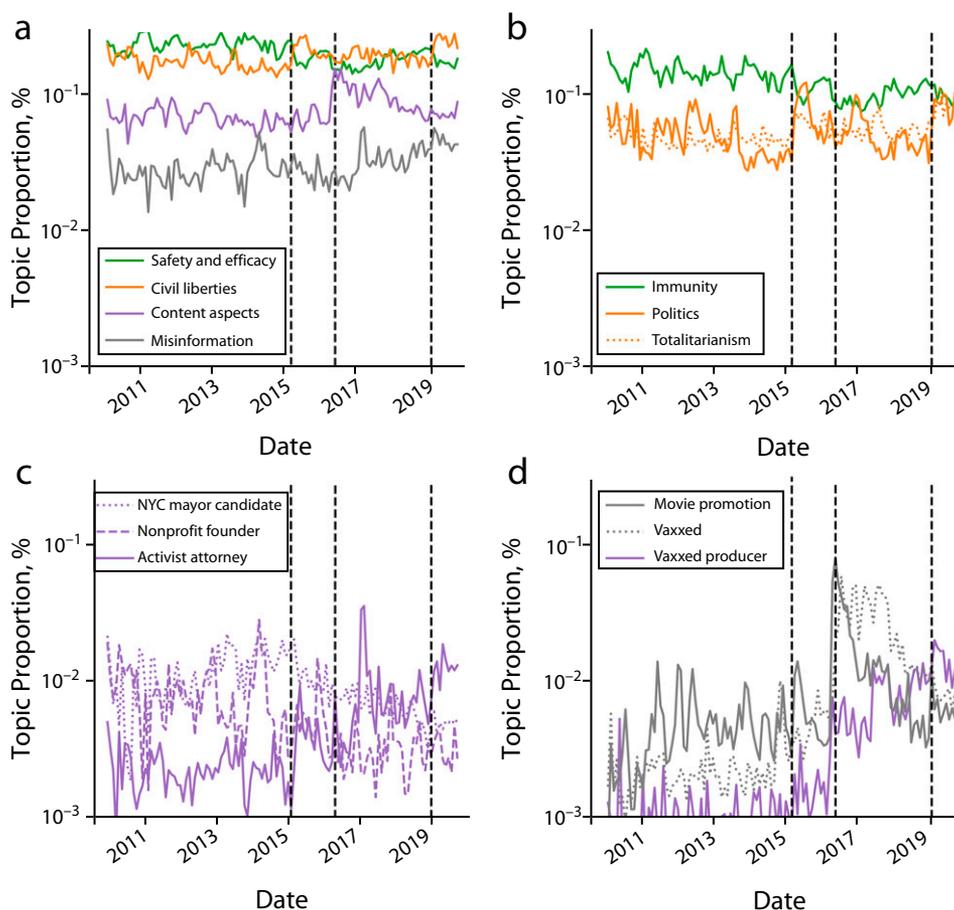
Phase 2

The launch of *Vaxxed* coincided with an increase in posts to non–state-specific civil liberties pages. However, the proportion of civil liberties topics discussed decreased whereas the proportion of posts about the movie increased. This suggests that these

pages may have been used as vehicles to disseminate content advertising the movie, possibly having established a linkage between the civil liberties discourse and the personalities driving this movie’s agenda. This interpretation is supported by a decrease in civil liberties content in civil liberties pages, such that these pages more directly mirrored the content of other pages (Figure 3). This coincided with an increase in references to the movie’s producer and collaborator during the same time period (Figure 2d, in particular, shows a large spike in January 2017). Fans of civil liberties pages may have been explicitly targeted as audiences for this movie.

Phase 3

The year 2019 gave rise to a sharp increase in posts to pages mobilizing Facebook fans for political purposes. This effect is especially pronounced in US state pages, which have seen increases in civil liberties discourse, but also vaccine safety concerns and alternative medicine. Michigan, Oregon, Georgia, New England, and Delaware seem to have been especially targeted. Notably, several of these regions were sites of measles outbreaks in 2019, a focus of legislative debate regarding



Note. Vertical lines indicate the “Disneyland” measles outbreak (January 2015), the launch of *Vaxxed* (April 2016), and the 2019 measles epidemic in January 2019. All proportions are plotted on a logarithmic axis.

FIGURE 2—Monthly Proportion of Posts Pertaining to (a) Selected Typology Categories, (b) Selected Safety and Efficacy and Civil Liberties Content Attributes, (c) Self-Referencing Topics, and (d) Topics Pertaining to *Vaxxed*, the Movie: October 2009–October 2019

vaccines, or both. For example, Georgia’s House Bill 615 would “authorize certain minors to receive vaccinations without parental consent” (<http://www.legis.ga.gov/Legislation/en-US/display/20192020/HB/615>). Finally, among nonstate pages, only civil liberties pages experienced a similar increase whereas other topics declined in volume.

These findings were replicated in the topic analysis, which showed that both 2015 and 2019 saw a sharp increase in the civil liberties discourse, attributed largely to increased discussions about political mobilization and totalitarianism. By contrast, discussion of safety and efficacy has decreased, suggesting that vaccine opponents increasingly oppose vaccination as a matter of political principle rather than because of any particular concern about harms.

Emergence of a Common Vaccine Opponent Narrative

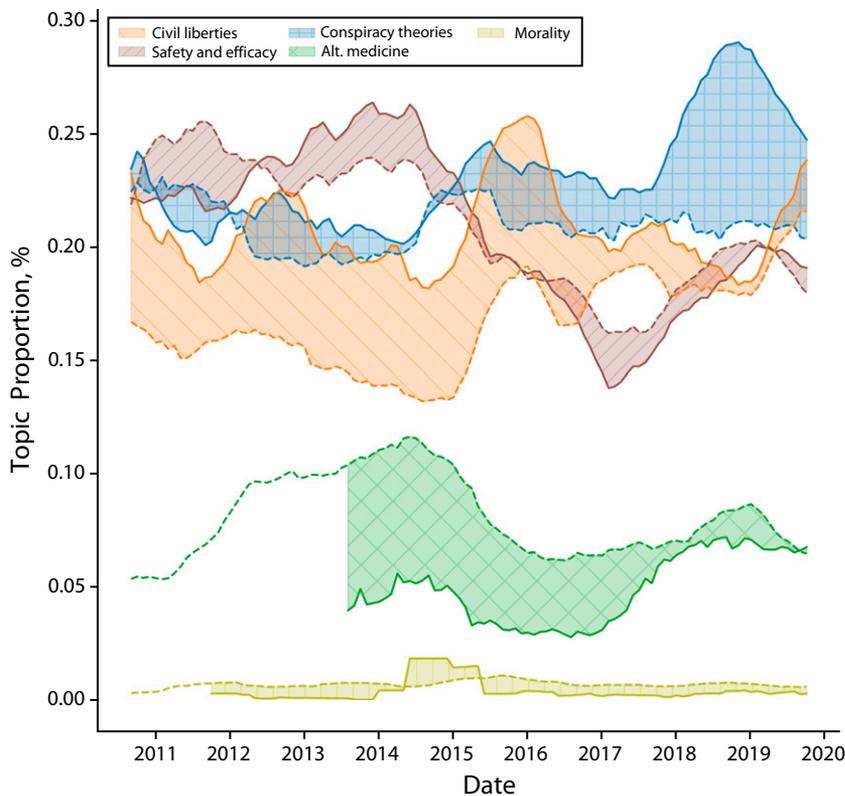
All categories of vaccine pages appear to increasingly reflect the same proportion of topics regardless of the stated purpose of the page. Furthermore, a large and increasing proportion of these messages reflect civil liberties and especially totalitarianism and political mobilization. This raises questions regarding to what extent there may be coordinated action driving content to these pages, with common ideological, political, or commercial commitments.

Limitations

A labeling error by 1 annotator led us to inadvertently exclude 1 page (1% of posts)—that claimed to promote “understanding of”

or “truth about” vaccines, but actually opposed vaccines—from our sample. Beyond this 1 error, we utilized trained annotators with subject matter expertise to achieve reliable results.

In general, Facebook pages reflect “the official profiles for entities, such as celebrities, brands or businesses”³⁰ constituting a limited snapshot of Facebook’s dynamic network structure. By contrast, Facebook groups are designed for people to “share their common interests and express their opinion.”³⁰ Pages often point to eponymous groups, suggesting similar content; however, future work should conduct a more extensive comparison. Furthermore, private groups are inaccessible to ethical researchers whereas all pages are public. Although some content may have been removed before data collection, these



Note. Solid lines reflect the proportions of posts in pages that are consistent with that topic category (e.g., proportions civil liberties topics in civil liberties groups). Dashed lines reflect the proportions of posts in pages that are not consistent with that topic category (e.g., proportions of civil liberties topics in non-of civil liberties groups). Pages pertaining to morality and alternative medicine did not contain any posts until October 2010 and September 2012, respectively. (See Appendix A, Figure G, available as a supplement to the online version of this article at <http://www.ajph.org>, for figure without averaging.)

FIGURE 3—Monthly Proportions of Facebook Posts Pertaining to Each Page Category, Calculated Using a 12-Month Moving Average for Readability: October 2010–October 2019

removals appear limited—only 10 pages did not return any posts—compared with the millions of fans and hundreds of thousands of posts in our sample.

Public Health Implications

Health communicators frequently focus their efforts on debunking misinformation and promoting the health benefits of vaccination to the public. By contrast, vaccine opponents increasingly use the language of civil liberties—such as “vaccine choice”—to frame their efforts.

There is scientific consensus regarding the safety and efficacy of vaccination. Nevertheless, a civil liberties frame implies a legitimate debate about vaccination. This frame is known to increase hesitancy and delay—and, therefore, the likelihood of outbreaks—even

among those who believe that vaccines are safe and effective.⁸ Furthermore, this frame puts the impetus for making what would otherwise be a routine procedure on vulnerable parents. Finally, framing vaccination as an individual choice shifts attention away from the social rationales for vaccination, including that herd immunity is a key factor in protecting the most vulnerable patients—the immunocompromised and the elderly.³¹

A freedom-of-choice frame has previously been adopted by vaccine opponents in other countries¹⁹ and by the tobacco industry when seeking to advance its business interests: this frame had been used to oppose government regulation by deflecting blame from corporate responsibility onto individual consumers.⁹ Vaccine opponents may similarly be using this frame to deflect attention from internal contradictions and significant internal

disagreements regarding specific safety concerns or conspiracy theories. For example, some vaccine opponents claim that vaccines cause the diseases that they actually prevent, whereas others claim that vaccines are unnecessary because associated illnesses were already declining. Given the shifting rationales for vaccine refusal, a “civil liberties” framing fundamentally recontextualizes vaccination, making it into a value-laden political issue, rather than a debate over scientific or medical facts.

To the extent that public health communications emphasize verbatim facts over the gist, or bottom-line meaning,^{32–34} of vaccination, vaccine opponents and proponents may be talking past one another, with proponents unable to convince opponents about the value of vaccination and conflating vaccine opposition with ignorance—a linkage that strengthens the claim that public health and medical officials are elitist. Thus, this framing presents health communicators with a danger and an opportunity. The danger is that public health practitioners, often with limited human and fiscal resources, cannot devote the sheer attention necessary to maintain a constant social media presence. Furthermore, they may wish to avoid the appearance of communications that could be judged to be partisan or political. By contrast, by empowering members of the public to make their own choices about vaccination, public health communicators must be equally empowered—but only if provided with adequate resources—to communicate the appropriate and compelling social context for vaccination decisions.

Our results suggest that vaccine opponents are becoming increasingly organized with considerable political clout. Public health agencies and advocates must therefore build strong relationships with state policymakers so that they may take an active stance when proposed laws or exemptions would further threaten the public’s health. Finally, legislation is shaped by public opinion. Thus, continued protection of the public health will require sustained research into effective messages for communicating fact-based rationales for vaccination that are nevertheless targeted and tailored. These messages must be responsive to the contextual factors, specific values, and gists motivating vaccine refusal. **AJPH**

CONTRIBUTORS

D. A. Broniatowski designed the study, collected and analyzed data, conducted the statistical analyses, and wrote the first draft of the article. A. M. Jamison assisted with study design, critically revised the article, and conducted the qualitative analysis. N. F. Johnson, N. Velasquez, R. Leahy, and N. Johnson Restrepo collected and labeled data and critically revised the article. M. Dredze critically revised the article. S. C. Quinn critically revised the article and assisted with study design.

ACKNOWLEDGMENTS

Research reported in this publication was supported in part by the National Institute of General Medical Sciences of the National Institutes of Health under award 5R01GM114771 and by the John S. and James L. Knight Foundation through a grant to the Institute for Data, Democracy, and Politics at The George Washington University.

The authors would like to thank Emma Schreier for her work labeling Facebook pages.

Note. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health or the John S. and James L. Knight Foundation. None of the funding sources had any role in study design.

CONFLICTS OF INTEREST

D. A. Broniatowski has received an honorarium of \$500 from the United Nations Shot@Life Foundation—a nonprofit organization that promotes global childhood immunization. M. Dredze holds equity in Sickweather and has received consulting fees from Bloomberg LP and Good Analytics. N. F. Johnson, N. Velasquez, R. Leahy, and N. Johnson Restrepo occasionally act as consultants to outside companies, but they do not and have not acted in this capacity with any company related to the content of this article, nor more generally in public health or on the topic of vaccines. None of the organizations or companies listed here had any role in the study design, data collection and analysis, decision to publish, or preparation of the article.

HUMAN PARTICIPANT PROTECTION

The data used in this article are from publicly available online sources, the uses of which are deemed exempt by the George Washington University institutional review board (180804).

REFERENCES

- Perrin A, Anderson M. Share of US adults using social media, including Facebook, is mostly unchanged since 2018. Pew Research Center. April 10, 2019. Available at: <https://www.pewresearch.org/fact-tank/2019/04/10/share-of-u-s-adults-using-social-media-including-facebook-is-mostly-unchanged-since-2018>. Accessed June 7, 2019.
- Breland JY, Quintiliani LM, Schneider KL, May CN, Pagoto S. Social media as a tool to increase the impact of public health research. *Am J Public Health*. 2017;107(12):1890–1891. <https://doi.org/10.2105/AJPH.2017.304098>
- Luxton DD, June JD, Fairall JM. Social media and suicide: a public health perspective. *Am J Public Health*. 2012;102(suppl 2):S195–S200. <https://doi.org/10.2105/AJPH.2011.300608>
- Chou WS, Oh A, Klein WMP. Addressing health-related misinformation on social media. *JAMA*. 2018;320(23):2417–2418. <https://doi.org/10.1001/jama.2018.16865>
- Southwell BG, Niederdeppe J, Cappella JN, et al. Misinformation as a misunderstood challenge to public health. *Am J Prev Med*. 2019;57(2):282–285. <https://doi.org/10.1016/j.amepre.2019.03.009>
- Schmidt AL, Zollo F, Scala A, Betsch C, Quattrocchi W. Polarization of the vaccination debate on Facebook. *Vaccine*. 2018;36(25):3606–3612. <https://doi.org/10.1016/j.vaccine.2018.05.040>
- Del Vicario M, Vivaldo G, Bessi A, et al. Echo chambers: emotional contagion and group polarization on Facebook. *Sci Rep*. 2016;6(1):37825. <https://doi.org/10.1038/srep37825>
- Broniatowski DA, Jamison AM, Qi S, et al. Weaponized health communication: Twitter bots and Russian trolls amplify the vaccine debate. *Am J Public Health*. 2018;108(10):1378–1384. <https://doi.org/10.2105/AJPH.2018.304567>
- Ingram M. Facebook now linked to violence in the Philippines, Libya, Germany, Myanmar, and India. *Columbia Journalism Rev*. September 5, 2018. Available at: https://www.cjr.org/the_media_today/facebook-linked-to-violence.php. Accessed January 18, 2020.
- Betsch C, Brewer NT, Brocard P, et al. Opportunities and challenges of Web 2.0 for vaccination decisions. *Vaccine*. 2012;30(25):3727–3733. <https://doi.org/10.1016/j.vaccine.2012.02.025>
- Smith MJ, Marshall GS. Navigating parental vaccine hesitancy. *Pediatr Ann*. 2010;39(8):476–482. <https://doi.org/10.3928/00904481-20100726-05>
- Dubé E, Vivion M, MacDonald NE. Vaccine hesitancy, vaccine refusal and the anti-vaccine movement: influence, impact and implications. *Expert Rev Vaccines*. 2015;14(1):99–117. <https://doi.org/10.1586/14760584.2015.964212>
- Jolley D, Douglas KM. The effects of anti-vaccine conspiracy theories on vaccination intentions. *PLoS One*. 2014;9(2):e89177. <https://doi.org/10.1371/journal.pone.0089177>
- Jones AM, Omer SB, Bednarczyk RA, Halsey NA, Moulton LH, Salmon DA. Parents' source of vaccine information and impact on vaccine attitudes, beliefs, and nonmedical exemptions. *Adv Prev Med*. 2012;2012:932741. <https://doi.org/10.1155/2012/932741>
- Pennycook G, Cannon TD, Rand DG. Prior exposure increases perceived accuracy of fake news. *J Exp Psychol Gen*. 2018;147(12):1865–1880. <https://doi.org/10.1037/xge0000465>
- Johnson NF, Velásquez N, Restrepo NJ, et al. The online competition between pro- and anti-vaccination views. *Nature*. 2020;582:230–233. <https://doi.org/10.1038/s41586-020-2281-1>
- Kata A. Anti-vaccine activists, Web 2.0, and the postmodern paradigm—an overview of tactics and tropes used online by the anti-vaccination movement. *Vaccine*. 2012;30(25):3778–3789. <https://doi.org/10.1016/j.vaccine.2011.11.112>
- Dredze M, Broniatowski DA, Smith MC, Hilyard KM. Understanding vaccine refusal: why we need social media now. *Am J Prev Med*. 2016;50(4):550–552. <https://doi.org/10.1016/j.amepre.2015.10.002>
- Kennedy J. Populist politics and vaccine hesitancy in Western Europe: an analysis of national-level data. *Eur J Public Health*. 2019;29(3):512–516. <https://doi.org/10.1093/eurpub/ckz004>
- Johnson NF, Zheng M, Vorobyeva Y, et al. New online ecology of adversarial aggregates: ISIS and beyond. *Science*. 2016;352(6292):1459–1463. <https://doi.org/10.1126/science.aaf0675>
- Johnson NF, Leahy R, Restrepo NJ, et al. Hidden resilience and adaptive dynamics of the global online hate ecology. *Nature*. 2019;573(7773):261–265. <https://doi.org/10.1038/s41586-019-1494-7>
- Johnson NF, Velasquez N, Restrepo NJ, et al. Health wars and beyond: the rapidly expanding and efficient network insurgency interlinking local and global online crowds of distrust. *ArXiv191002103 Phys*. October 4, 2019. Available at: <http://arxiv.org/abs/1910.02103>. Accessed November 16, 2019.
- CrowdTangle Team. *CrowdTangle*. 2019. Available at: <https://apps.crowdtangle.com/iddptest/lists/1299642>. Accessed July 28, 2020.
- Kata A. A postmodern Pandora's box: anti-vaccination misinformation on the Internet. *Vaccine*. 2010;28(7):1709–1716. <https://doi.org/10.1016/j.vaccine.2009.12.022>
- Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33(1):159–174. <https://doi.org/10.2307/2529310>
- Broniatowski DA, Hilyard KM, Dredze M. Effective vaccine communication during the Disneyland measles outbreak. *Vaccine*. 2016;34(28):3225–3228. <https://doi.org/10.1016/j.vaccine.2016.04.044>
- Wallach HM, Mimmo DM, McCallum A. Re-thinking LDA: why priors matter. In: *Advances in Neural Information Processing Systems*. San Diego, CA: Neural Information Processing Systems; 2009:1973–1981.
- Blei DM. Probabilistic topic models. *Commun ACM*. 2012;55(4):77–84. <https://doi.org/10.1145/2133806.2133826>
- Griffiths TL, Steyvers M. Finding scientific topics. *Proc Natl Acad Sci U S A*. 2004;101(suppl 1):5228–5235. <https://doi.org/10.1073/pnas.0307752101>
- Facebook. Facebook tips: what's the difference between a Facebook page and group? February 24, 2010. Available at: <https://www.facebook.com/notes/facebook/facebook-tips-whats-the-difference-between-a-facebook-page-and-group/324706977130>. Accessed June 26, 2020.
- Quinn SC. Probing beyond individual factors to understand influenza and pneumococcal vaccine uptake. *Am J Public Health*. 2018;108(4):427–429. <https://doi.org/10.2105/AJPH.2018.304326>
- Reyna VF. Risk perception and communication in vaccination decisions: a fuzzy-trace theory approach. *Vaccine*. 2012;30(25):3790–3797. <https://doi.org/10.1016/j.vaccine.2011.11.070>
- Reyna VF. A theory of medical decision making and health: fuzzy trace theory. *Med Decis Making*. 2008;28(6):850–865. <https://doi.org/10.1177/0272989X08327066>
- Reyna VF. A scientific theory of gist communication and misinformation resistance, with implications for health, education, and policy. *Proc Natl Acad Sci U S A*. 2020; Epub ahead of print. <https://doi.org/10.1073/pnas.1912441117>

Copyright of American Journal of Public Health is the property of American Public Health Association and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.