Behavioural interventions to reduce vaccine hesitancy driven by misinformation on social media

Kai Ruggeri and colleagues vaccine misinformation on social media has strong effects on behaviour, and the evidence base for interventions to reduce these effects is limited, but better approaches to evidence generation are possible

Effective population level vaccination campaigns are fundamental to public health.[1-3] Counter campaigns, which are as old as the first vaccines,[4] disrupt uptake and can threaten public health globally.[4] In 2019, public health researchers linked increases in measles cases with the proliferation of global anti-vaccine campaigns.[5] Some of these campaigns originated offline but were later amplified and expedited through social media, resulting in real world harms.[6] Though crises and genuine safety concerns can also lower vaccine uptake,[7 8] the return of measles after aggressive anti-vaccine campaigns prompted the World Health Organisation to list vaccine hesitancy among the greatest threats to global health (box 1).[14]

Anti-vaccine campaigns proliferated during the covid-19 pandemic[15] with undeniable effects including substantial increases in covid related illness and death.[15-17] Even before March 2020, vaccine hesitancy was directly linked to misinformation (false, inaccurate information promoted as factual) spread on social media.[18] Once covid-19 reached pandemic status, social media was acknowledged as the epicentre of misinformation leading to hesitancy,[19 20] and consequently, interventions to tackle hesitancy have globally focused on delivery through social media.[21 22]

Despite unprecedented levels of vaccine access and nearly real time communication on the development and availability of vaccines in 2020-21, public health officials struggled to keep pace with misleading or inaccurate content online.[23] As guidelines shifted with the emergence of new information, policy decisions were often perceived by individuals and groups who are prone to distrust or refute government messaging as a response not to evidence but to mistakes or lack of expertise.[24 25] A 2021 randomised controlled trial (RCT) found that exposure to misinformation about covid-19 vaccines lowered the intent of recipients to vaccinate, even among those reporting before exposure that they would "definitely" accept vaccination.[21] Similar findings globally indicate that social media dynamics exacerbated the sharing of misinformation, reduced vaccination rates, undermined trust in reliable information, magnified polarisation, and damaged the perceived credibility of institutions.[26-30] These challenges remain today.

Approaches to reducing vaccine hesitancy

Standard behavioural approaches to encourage vaccination include mandatory vaccination and regulation for healthcare professionals, incentives, public health communication campaigns, and engaging trusted leaders.[31] Contemporary methods have started to be implemented on social media,[10 31-33] including debunking (fact checking specific claims after they have reached social media users) and "prebunking," a behavioural approach in which users are taught about how "fake news" works before exposure.[34] Other intervention types include warning ("inoculating") people about manipulation tactics using non-harmful exposure as a tool to identify misinformation, and using accuracy prompts to trigger people to consider the truthfulness of material they are about to share on social media platforms, without stopping them from posting.[35] Recognising the intense effect of social media on vaccine hesitancy,[36] the Africa Centres for Disease Control and Prevention developed a toolkit to assist countries in social media strategies aimed at encouraging vaccination.[37]

Such behavioural approaches to misinformation on social media have shown promise in reducing the sharing of disinformation and misinformation (box 1) and in changing people's beliefs,[38] but less clear is their effect on vaccination uptake. Investigating the success of such interventions on uptake is essential because there is an established link between social media exposure and offline beliefs that vaccines are unsafe.[39] It is clear, however, that providing fact based probabilistic information alone fails to meaningfully increase uptake[40] and might even backfire.[41] Factors such as low trust in governments and health institutions are likely to be instrumental in derailing effective immunisation programmmes.[42] Multiple drivers and barriers to vaccine uptake must therefore be considered when developing effective tools.

Evaluating interventions to reduce vaccine hesitancy

We identified 30 studies evaluating interventions to tackle misinformation on social media that explicitly captured real world behavioural outcomes (see supplementary information on bmj.com). After excluding 19 studies for lack of external validation, only 11 published interventions were left (table 1; box 2; fig 1). There is clearly insufficient evidence from field studies on social media interventions. Only two interventions that met all criteria came from outside the US (Israel[43] and Nigeria[53]), with a recent study conducted in Nigeria producing perhaps the most robust level of evidence.

Some evidence exists from field studies that did not directly target misinformation but provided accurate and useful information about vaccines. These were typically posted on interactive websites or directly in social media feeds. Changes in attitudes, knowledge, and social media

KEY MESSAGES

- Substantial evidence shows the negative effects of vaccine misinformation on social media
- Evidence on the effectiveness of interventions to correct or mitigate misinformation is considerably more limited and rarely includes measures of true vaccine uptake
- The evidence available does indicate ways forward to develop better methods, particularly those that would be less likely to backfire in the way that blanket social media bans have
- The need for such actions is urgent

Box 1: Vaccine hesitancy

Here, we use the term "vaccine hesitancy" as originally defined by WHO[9]: a "delay in acceptance or refusal of vaccination despite availability of vaccination services." This definition, plus the expanded description of variation based on time, place, and population, gives a broad understanding but also allows us to distinguish vaccination behaviour from the underpinning psychological, environmental, and structural aspects influencing behaviour. This definition is most commonly used in literature pre-dating covid-19. Though there are debates about the most appropriate terms ("vaccine demand" is an alternative, for example) or updated definitions (including the updated WHO version) to use, applying the original WHO definition ensured that we captured relevant insights and evidence from the literature.[10-13] We also identify disinformation as a form of misinformation that deliberately seeks to mislead or otherwise disrupt understanding, although we cover both broadly under misinformation for the purposes of this paper.

engagement were reported for several information campaigns using social media advertisements in before and after designs and designs without control groups.[44 45 47 48] But these studies showed no changes in vaccination behaviours. Only two studies, both RCTs, showed that tackling vaccination concerns and providing information in interactive formats on a website increased vaccination[46] and reduced days undervaccinated.[51]

Two interventions that increased vaccination uptake used targeted messages through Facebook adverts[57] and personalised influencer content.[58] But each had limitations. In the first, vaccination rates increased only among families of medium-low socioeconomic status, indicating narrow effectiveness. In the second, the measures were primarily attitudinal, and behavioural outcomes were self-reported.

Linking online campaigns to true behaviours in field studies is a major challenge. This is partly because running well controlled studies is simpler in laboratory experiments and surveys, and because capturing distal effects (true behaviours) of web based studies is often impossible. But showing some measures of success in increasing uptake is necessary to justify investment to develop interventions at scale. Therefore, it is critical that researchers of vaccine behaviours and associated campaigns engage directly with clinics and public health agencies to improve the ecological and external validity (that is, real world, observed outcomes) of interventions (box 2).

Developing better interventions to confront vaccine hesitancy on social media

Few interventions among those we evaluated captured evidence about real world behaviours, so there is currently no gold standard toolkit that public health agencies can refer to.[56] But the evidence available can inform future tool development. We provide 10 insights based on the existing evidence that should help provide a clearer and more specific, evidence driven toolkit of approaches to reduce vaccine hesitancy.

- *Negative sentiments on social media might increase vaccine hesitancy faster than interventions reduce it*[39 59]—Although vaccine hesitancy can stem from many sources, including mass media and political rhetoric as well as genuine safety concerns, there is ample evidence of a proliferation of anti-vaccine messages on social media leading to organised offline actions and increased hesitancy.[60] This is driven by several social and individual factors, as well as foreign disinformation campaigns and bots.[61 62] There is less evidence that efforts to specifically mitigate misinformation have had a reliable effect on real world vaccine uptake.
- *Messaging seems to work best when it is tailored to what groups know and care about*—Two relatively large vaccination interventions, one for flu, one for human papillomavirus (HPV), found modest effects through targeting specific groups. Broad campaigns through all forms of media tend to be generally effective. But once misinformation and conflicting views are prevalent, speaking directly to audiences, knowing the reasons for hesitancy, and framing information in a way that matters to individuals are critical.[54 63 64]
- *Simple messaging about benefits and risk based on probabilities is not enough*—Filling vaccine knowledge gaps has direct benefits, such as supporting informed decisions,[63] but messaging with information about benefits, harms, and associated probabilities is insufficient to resolve vaccine hesitancy.[40] Some possible explanations include lack of trust and cultural values, which have a major effect on how scientific data are interpreted and accepted through social media.[65] Messages must be conveyed in a way that affirms individual cultural values,[66] dealing with topics of importance to individuals, not only health facts, using credible sources of information.[67] Visual imagery also helps deliver effective messages,[68] and other components should be considered, such as health literacy, simplified language, and context specific features like age or language.
- *Correct misinformation to both parents and their children*—Parents, especially mothers, play a major part in child vaccination.[58] One large campaign carried out on Facebook directed at mothers of teens had some positive effects in specific income groups, but the overall effect was minimal to null. Addressing parents is clearly of value, but young people also seek out information online for themselves.[69] Thus, the information teens are presented with online likely needs similar but unique safeguards against misinformation to the ones discussed. Directly involving parents and young people in the design of messaging might strengthen the effectiveness of these campaigns.[70]
- *Trust matters: the message*,[71] *the messenger*,[63] *and the (vaccinated) provider*[57]—Substantial amounts of anti-vaccine messaging comes from non-medically qualified, or non-expert, voices on social media.[72] Thus, medical professionals are under-represented when it comes to legitimate and accurate information about vaccines on social media,[73] despite typically being the most trusted sources (especially among parents[74]). Trust is potentially the most distinct characteristic of successful vaccination campaigns,[50 75] and this includes ones delivered on social media.[76] Ultimately, the source of the message—whether a healthcare provider, a politician, or a social media influencer—is likely to have a major role in whether individuals and communities deem information to be credible.[57 63] These interventions have great potential when delivered to the right population.[30] The US state of New York, for example, was a stronghold of anti-vaccine sentiment before 2020, which pivoted after the arrival of covid-19. Despite intensifying hesitancy and misinformation waves, the state outpaced the national average for vaccination rates, benefiting both public health[77] and economic returns.[78]

Table 1 | Interventions to reduce vaccine hesitancy through social media that assessed real world vaccine behaviours

Study and country	Vaccine	Demographics	Type of hesitancy	Methods	Intervention and outcome
Chodick et al. (2021)[43] Israel	HPV	Mothers of teen daughters	Lack of knowledge	RCT	Facebook adverts addressing issues and concerns about HPV and the vaccine with inoculation elements had positive effects on vaccination rates in the second quarter by socioeconomic status, a negative effect in the lowest quarter, and no effect in higher socioeconomic levels
Brandt et al. (2020)[44] USA	HPV	College students	Underestimating severity and susceptibility	Questionnaires	Facebook group posts, weekly emails, and open-ended reflection appealing to personal benefits and health education showed increased knowledge but had no significant effect on self-reported vaccination
Bonnevie et al. (2020)[45] USA	Flu	African American and Hispanic US residents	Group norms	Before and after	Influencer created content campaigns showed increases in positive vaccine beliefs and small but non-significant effects on self-reported vaccination
O'Leary et al. (2019)[46] USA	Tdap, flu	Pregnant women	Concerns about vaccines due to providers' lack of time and resources to inform	RCT	A website with vaccine information and interactive social media components had medium positive effects on vaccination rates specifically among pregnant women
Ortiz et al. (2019)[47] USA	HPV	Adolescents	Lack of knowledge	Before and after	Health facts appearing in Facebook news feed every 4 to 5 days showed increased knowledge but no effect on vaccinations
Mohanty et al. (2018)[48] USA	HPV	Adolescents	Lack of knowledge and awareness	Intervention without control	Facebook advertisement campaigns directing to a website to schedule vaccination reached a large audience but had no effects on vaccination rates.
Sundstrom et al. (2018)[49] USA	HPV	College-age women	Underestimating severity and susceptibility	Focus groups and survey	Information posts on several social media outlets increased self-reported vaccination, though no statistical test was conducted
Huang et al. (2018)[50] USA	Flu	Undergraduate students		Difference in difference	Social media campaign appealing to students' community identity had positive effects on vaccination rates
Glanz et al. (2017) [51] USA	Multiple early childhood vaccines	Pregnant women	Misinformation on social media	RCT	Website with vaccine information and interactive social media components reduced the days undervaccinated of infants with medium effects specifically among pregnant women
Shropshire et al. (2013)[52] USA	Flu	University students	Concerns about vaccines, underestimating susceptibility	Post-vaccination survey	Multimedia campaign about flu vaccine including social media outlets had positive effects on vaccination rates
Evans et al. (2023)[53] Nigeria	COVID-19	Facebook users	Lack of positive social norms	Quasi-experiment	Social media campaign focused on promoting pro-vaccination social norms using social influencers had positive effects on self-reported vaccination.

This success is attributed to strategies that, on top of tackling misinformation, also cultivated trust in the source of the vaccine, the messenger, and the provider, involving use of the military (a highly trusted organisation in the US), diverse community messengers (including community health workers and faith leaders), and a broad network of vaccination locations.[79-82] These aspects must be ensured in public campaigns aimed at specific groups, especially those who are vaccine hesitant.[64]

- *Debunking efforts have shown mixed effects on social media*—Distributing information from public institutions or providing objective information from third parties might help to counter misinformation, reduce the intention to spread misinformation, and promote health behaviours, but the process is not always smooth. The backfire effect is a concerning pattern in which disproving misinformation reinforces it and deepens false beliefs.[83] But this phenomenon is not consistently observed in practice. Effects of debunking might be highly dependent on the recipient's background knowledge and beliefs, methods of presentation, and what other information is viewed.[84-85] For now, the immediate priority for this approach is to determine if inoculation based on pre-bunking can reliably reduce the noxious effects of next widespread waves of misinformation and resulting misbeliefs.
- *Raising the quality and visibility of reliable health information can counter misinformation*—Providing simple probabilistic information is not likely to completely counteract misinformation

Box 2: A robust research agenda for social media interventions is needed

Studies on reducing vaccine hesitancy can inform broader vaccination messaging campaigns. We recommend some critical features that should be included for all interventions (fig 1). Details about the type of vaccine and the target group should be highly specific, as should the form of hesitancy and misinformation,[54] the misinformation source, and details of the method (especially for RCTs). Real world effects (ideally direct and broader public health indicators) must be captured. These aspects are relevant for better understanding of what might work and for what reasons and for comparison between methods and social media platforms. The most informative approach would cover the first three levels of evidence under the THEARI system (theoretical, empirical, and real world).[55] Over time, these would accumulate to the fourth (replicated) and fifth (well established impact) levels, maximising the potential for predictive validity of applications to public policy (for example, greater confidence in anticipated effects). Doing so would exceed the criteria listed in a recent call for a gold standard for trials tackling vaccine hesitancy.[56]

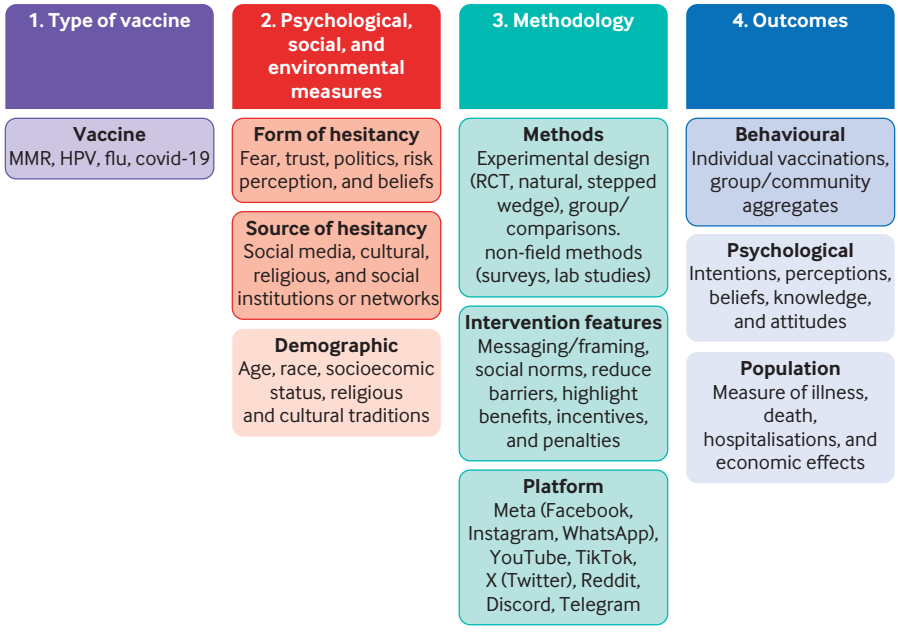

Fig 1 | Critical aspects of studies that are necessary to better understand and compare possible interventions that tackle vaccine hesitancy on social media (described in box 2). The examples of what specifically to measure and observe are non-exhaustive. All aspects should be included for maximum value, though behavioural and population health outcomes should be prioritised.

on its own, but providing information on how, where, and when to get a vaccine does.[76] The high volume of misinformation appearing in online searches, however, can override more reliable sources,[86] limiting the effectiveness of high-quality information campaigns.[87] To increase campaign effectiveness, interactive designs and visual aids such as posters or videos help target populations see and engage with accurate, accessible information throughout a campaign.[51] Making it easier to find such materials is paramount, starting with search engine optimisation to increase visibility of campaigns.

- *Framing of vaccine messages matters*—How public campaign messaging is framed affects health decision making. A public campaign can't cover all vaccines, diseases, populations, and reasons for hesitancy; framing messages to be directly relevant to a populations' needs (benefits and risks specific to their group) have resulted in significant increases in uptake.[88] Positive and negative framing effects are not equivalent,[89] however, and this should be factored into messaging decisions.
- *Blanket bans can drive groups and activities underground*—Broad social media bans of individuals or of specific content can paradoxically result in the spread of misinformation and can galvanise problematic echo chambers by driving discussion into private social media groups or closed forums.[90 91] Such closed environments are unlikely to include different viewpoints or corrective information, so misinformation is more likely to be reinforced. Rather than rely on outright bans, policy makers and content managers should explore methods that limit the spread and influence of misinformation.[92]
- *Social media platforms need to be part of the solution*—If social media platforms are the epicentre of misinformation, then social media companies need to be part of the solution.[39] During the covid-19 pandemic, social media platforms took a more interventionist approach to content moderation than before (and, in some cases, removed or limited covid-19 misinformation and conspiracies).[93] Some of these approaches are now being rolled back, and social media researchers' access to data about behaviour on the global platform X (formerly Twitter) is being limited. Content labelling and corrective actions have produced some positive effects,[94] but social media companies should be more proactive in dealing with the proliferation of misinformation on their sites.[95] We endorse calls[39] to make data available and to work with researchers and regulators in all countries to enable developing effective solutions.

It is worth it to get these campaigns right

Misinformation is not new and its noxious consequences are not insurmountable, but its effect on vaccine hesitancy through social media is an urgent global threat to public health. Increasingly robust evidence has shown the drivers and effects of this phenomenon, but few successful, let alone replicated, interventions exist. One important step towards developing more effective interventions is the close monitoring of public perceptions and opinions about vaccination and services. Digital technologies make it possible to analyse large quantities of "social listening data" in real time.[96] Such information would complement the evidence we already have from a variety of study types, improving the design of new, robust, and appropriately targeted interventions. Because most published interventions focused on attitudes and intentions rather than on actual vaccination, however, there remains an urgent need for direct partnerships between behavioural researchers with healthcare clinics and public health agencies.[77] Meaningfully developing those partnerships promises direct benefits for more reliable scientific insights that would improve the health and well being of entire populations.

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Supplementary information: Methods and excluded studies

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