

# COVID-19 Pandemic and its Impact on Vaccine Hesitancy: A Review

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## ARTICLE INFO

### Article history:

Received: 16 April 2024

Accepted: 10 June 2024

### Online:

DOI 10.5001/omj.2024.103

### Keywords:

Anti-Vaccine; COVID-19 Vaccine; Vaccine Hesitancy; Pandemic; Vaccination.

## ABSTRACT

Vaccination is one of the most successful public health initiatives in human history, significantly reducing the incidence and severity of infectious diseases. The success of any vaccination program depends on several factors, including effective leadership, funding, distribution management, and addressing vaccine hesitancy. Vaccine hesitancy, the delay or refusal to be vaccinated despite the availability of immunization services, has always been prevalent in societies but has become more pronounced during the COVID-19 pandemic. During the pandemic, anti-vaccine activists persistently promoted and increased vaccine hesitancy by using social media to spread rumors, propaganda, and conspiracy theories. The rising vaccine hesitancy among the public became a major challenge to the success of the COVID-19 immunization program. There are also indications that this hesitancy may have generalized against more traditional vaccines. This literature review explores the structure and evolving dynamics of COVID-19 vaccine hesitancy and the resultant generalized skepticism towards other vaccinations. It also suggests future strategies to address and mitigate the phenomenon of vaccine hesitancy.

COVID-19 was the most devastating public health crisis of the century. In the first two years of the pandemic (January 2020 to December 2021), nearly six million deaths were reported globally.<sup>1</sup> The healthcare sector worldwide was stretched beyond limits. Under the leadership of the World Health Organization (WHO), countries and organizations around the world initiated organized strategies to slow down the spread of the virus, including imposing lockdowns, mask-wearing, and social distancing. The healthcare industry and scientists collaborated across national borders, sharing epidemiological data, and research findings.

As a result of such unprecedented collaboration, researchers from different countries and institutions were able to produce COVID-19 vaccines in record time, which helped control the pandemic.<sup>2</sup> The vaccines produced by Oxford-AstraZeneca, Moderna, Janssen, and Pfizer-BioNTech were reported to have > 80% effectiveness in preventing SARS-CoV-2 infections within 12–42 days post-vaccination.<sup>3</sup> Even though their effectiveness declined after around 112 days following vaccination, booster doses could extend for a longer period.<sup>4</sup> A systematic

review found that COVID-19 vaccine was cost-effective in overcoming the pandemic.<sup>5</sup> Despite the benefits of the COVID-19 vaccine, the spread of misinformation by social media increased vaccine hesitancy in a section of the world population.<sup>6</sup>

For vaccination programs to succeed, several measures need to be implemented. These include efficient leadership, vaccination workforce, service delivery, financing, and distribution.<sup>7</sup> Apart from these, there is a need to address vaccine hesitancy among the public and a minority of medical professionals,<sup>7</sup> which is especially difficult to tackle because it arises from the complex interplay of many psychosocial variables including cultural, psychological, and individual health beliefs, misinformation, trust in healthcare providers and the government, as well as the dilemma between the perceived risk of the disease versus that of the vaccine. A qualitative study conducted in Germany revealed that some individuals were hesitant to accept the COVID-19 vaccine because they believed it was developed in an unusually short period and insufficiently tested before being approved for emergency public distribution.<sup>8</sup> A study in the Philippines also revealed similar perceptions.<sup>9</sup>

This literature review explored vaccine hesitancy during the COVID-19 pandemic and its impact on the vaccination campaign. Following the COVID-19 era, vaccine hesitancy appears to have been increasing, mainly fueled by widespread misinformation and conspiracy theories. We will specifically discuss the reasons for COVID-19 vaccine refusal and explore strategies to address vaccine hesitancy in the future.

### ***Definition and determinants of vaccine hesitancy***

In 2014, the Strategic Advisory Group of Experts on Immunization (SAGE) Working Group defined vaccine hesitancy as a 'delay in acceptance or refusal of vaccines despite availability of vaccination services'.<sup>10</sup> They found that people who have chosen to vaccinate themselves and their children could develop hesitancy due to different reasons, for example, a fear of potential adverse events.<sup>11</sup> The Group developed a vaccine hesitancy model, known as the '3C model', based on three psychological variables: confidence, complacency, and convenience. Here, confidence relates to the perception of the safety and effectiveness of a vaccine. Complacency is influenced by the perception of whether an immunization program is successful. Convenience is affected by the accessibility and affordability of a vaccine.<sup>10</sup>

Further, the SAGE Working Group's matrix identified three categories of determinants that could influence vaccine hesitancy: (1) contextual influences, (2) individual and group influences, and (3) vaccine- or vaccination-specific influences. Contextual influences are related to sociocultural issues. Individual and group influences modify knowledge and attitudes toward health. Vaccine- or vaccination-specific influences cover all aspects of vaccines, such as risk and benefit, schedule, and costs.<sup>10</sup>

An example of the third category determinant of vaccine hesitancy occurred in 1990 when there was widespread public anxiety regarding thimerosal, a preservative used in the measles, mumps, and rubella vaccine as the cause of autism. Subsequent studies found no evidence to support this claim. However, in 1999, the USA Public Health Services and the American Academy of Pediatrics bowed to public pressure and recommended removing thimerosal from childhood vaccines.<sup>12</sup> Similarly, a recent study from Saudi Arabia reported that concerns about potential side effects as the most frequent reason for hesitancy regarding shingles vaccines.<sup>13</sup>

In some countries or regions, vaccine coverage is known to be influenced by religious and cultural beliefs. In the Bible Belt of the Netherlands, which is known for its conservative Protestant Christian community, there had been outbreaks of diseases like measles, mumps, rubella, and poliomyelitis in recent years. This was mainly because many people chose not to vaccinate their children due to their religious beliefs.<sup>14</sup> In the Canadian Bible Belt, a mumps outbreak in 2008 was attributed to low vaccination.<sup>15</sup> In Pakistan, there is a conspiracy theory that polio vaccination is an attempt by Israel and the USA to eliminate Muslims, leading to attacks on healthcare worker (HCWs) participating in polio vaccination campaigns.<sup>16</sup> In 2003, Muslim religious leaders in northern Nigeria banned polio vaccination among children due to a belief that the vaccine could lead to cancer and infertility, and spread HIV.<sup>17</sup>

Some Muslims in Guinea were reported to have refused to get vaccinated during Ramadan, due to their belief that nothing should enter the body during the fasting period. They were also concerned about any potential side effects of vaccination that might disrupt their fast.<sup>18</sup>

It is also suggested that the overall intensity of religious influence on vaccination intentions and practices may differ between religions. A study in Israel found that Jewish mothers were more likely to vaccinate their children against human papillomavirus than Muslim mothers.<sup>19</sup> Nine of the Sub-Saharan African countries reported lower coverage of childhood immunization in Muslim than in Christian families. Such inter-religious differences could also be associated with higher health literacy in Jewish and Christian societies.<sup>20</sup> In Indonesia, some parents refuse immunization, due to a suspicion that vaccines could contain pig-sourced substances.<sup>21</sup> This led to a demand among Indonesian Muslims for halal certification for rotavirus vaccines.<sup>22</sup> Accordingly, a vaccine manufacturer in Indonesia, Biofarma, has produced vaccines with halal certification. However, producing strictly halal vaccines is not easy because vaccine components are mostly produced by pharmaceutical firms in non-Muslim countries that may not fully understand halal requirements.<sup>23</sup>

### ***Hesitancy toward COVID-19 vaccines***

Vaccine hesitancy had a notable impact on the COVID-19 pandemic. Vaccine hesitancy and suboptimal public health interventions were

estimated to increase the risk of mortality by about 7.6 times.<sup>24</sup> A regression model by Dhalaria et al,<sup>25</sup> suggested that in India, a vaccine hesitancy of about 1% could lead to a decline of about 30% in vaccine coverage.

A 2021 study based on data from 23 countries reported that the actual availability of COVID-19 vaccines was associated with a decline in vaccine hesitancy from 28.5% in June 2020 to 24.8% in June 2021.<sup>26</sup> The exceptions were Russia, Nigeria, and Poland where people still retained high levels of vaccine hesitancy, about 48.4%, 43%, and 40.7%, respectively.<sup>26</sup> However, in the USA, measures such as Food and Drug Administration approval of COVID-19 vaccines and widespread vaccination programs were able to decrease vaccine hesitancy in all demographic categories. This decrease was particularly reported among African Americans and Hispanic communities, who previously had lower COVID-19 vaccination acceptance rates.<sup>27</sup>

Vaccine hesitancy has also been reported in a minority of HCWs. One study found that 3295 HCWs from 23 countries experienced vaccine hesitancy, with physicians having the lowest hesitancy levels.<sup>28</sup> The side effects and safety of vaccines were the most common reasons for vaccine hesitancy among healthcare providers.<sup>29</sup>

The occurrence of adverse events could also differ between various vaccine types.<sup>30</sup> Hence, this issue must be addressed strategically to cater to various populations' unique perceptions and vaccination experiences.

Studies about COVID-19 vaccine hesitancy began early in the pandemic before vaccines were developed. In March 2020, an anonymous cross-sectional survey in China revealed that 91.3% of participants were willing to accept a COVID-19 vaccine once it would become available, among whom 47.8% expressed an intention to wait until they could confirm that the vaccine was safe.<sup>31</sup> During September-October 2020, an online survey in the UK using the Oxford COVID-19 vaccine hesitancy scale, found that among 5114 adult respondents, 11.7% exhibited strong hesitancy. The main reasons were concerns about the potential side effects and the accelerated development of COVID-19 vaccines.<sup>32</sup> During the second wave of COVID-19 in Indonesia in 2021, a cross-sectional study found that 60.2% of 3014 adult participants had hesitancy towards COVID-19 vaccines. The primary reasons were: the speed of vaccine development and the potential

side effects.<sup>33</sup> A systematic review of observational studies in Nigeria reported that the acceptance rate of COVID-19 vaccines was below 60%, with concerns about vaccine safety and efficacy and sociodemographic factors playing significant roles.<sup>34</sup>

Several sociodemographic factors contribute to vaccine hesitancy, an important one being low education level.<sup>35</sup> Women were more hesitant because they worried about side effects, safety towards breastfeeding and pregnancy, and the effect on fertility.<sup>36,37</sup>

In Nigeria, mistrust of the government was found to be an important component in COVID-19 vaccine hesitancy.<sup>38</sup> Some Nigerian respondents suggested that the government was using the vaccine to make money in collaboration with foreign companies.<sup>39</sup> Some others believed that COVID-19 vaccine could be a tool for population control by injecting 'microchips' into the body.<sup>39</sup> Some believed that vaccines were meant to alter human DNA dangerously.<sup>39</sup> In another Nigerian study, where the COVID-19 vaccine acceptance rate was 28.2%, the respondents exhibited a high level of mistrust of the government, which stood at 56.8%.<sup>40</sup> Some respondents saw the COVID-19 pandemic as a punishment from God, portending 'end times'.<sup>39</sup>

The Internet has played a major role in spreading rumors that promote vaccine hesitancy. Even as early as 2009, 24% of the search results on vaccination on American websites were reported to have brought up anti-vaccination sites. Among the allegations propagated by such websites was that vaccines contained toxic substances such as mercury and formaldehyde.<sup>41</sup>

The advent of Web 2.0 empowered the public to generate and manage their online content via blogs and social media. This led to further proliferation of anti-vaccination propaganda. Strategies of the anti-vaccination groups include supporting flawed research and conspiracy theorists who claim that vaccines are dangerous.<sup>42</sup> The Center for Countering Digital Hate reported in 2020 that anti-vaccine accounts had widespread support, with 31 million Facebook followers and 17 million YouTube subscribers. Such propaganda led to people using the Internet, social media, and YouTube to become confused about the risk/benefits of vaccines and become increasingly vaccine-hesitant.<sup>43</sup>

In the past, anti-vaccine movements have used narratives such as, "vaccine is more dangerous rather than the disease itself", "vaccine is useless",

or “vaccination causes fatal disease”.<sup>44</sup> During the COVID-19 pandemic, many conspiracy theorists also began negating the existence of the disease itself (e.g. “COVID-19 is a big lie”, “COVID-19 is staged”, etc.).<sup>45</sup>

### ***Misinterpreting adverse events***

It is well known that all vaccines can cause adverse events in a tiny minority of recipients. COVID-19 vaccines are also not free of rare adverse events. A cohort study by Global Vaccine Data Network identified rare safety signals for Guillain-Barré syndrome and cerebral venous sinus thrombosis after administration of viral vector-based vaccines (AstraZeneca). The study also identified rare cases of myocarditis and pericarditis following mRNA-based vaccines (Pfizer and Moderna).<sup>46</sup> Another study documented a possible association between acute disseminated encephalomyelitis (ADEM) and transverse myelitis with viral vector and mRNA vaccines.<sup>47</sup> Such findings were exaggerated and misinterpreted by the proponents of anti-vaccination.

Successful conspiracy theories and fake news tend to contain a kernel of truth to make it seem scientific and believable, mixed with pseudoscience, misinterpretation of events, and connections. Such a powerful and persistent rumor began to spread in 2022, alleging that COVID-19 vaccines could induce severe liver hepatitis in children. We examine below how a kernel of scientific truth came to be misinterpreted and spread among the public.

Before the rollout of COVID-19 vaccines, Vojdani and Kharrazian predicted an increase in autoimmune diseases among COVID-19 patients.<sup>48</sup> In June 2022, WHO published a report on 930 probable cases of severe acute hepatitis in children with unexplained etiology, reported from 33 countries.<sup>49</sup> The WHO’s report noted that a minority of these children were COVID-19 positive, but it did not imply any connection between vaccination and these cases. A 2023 study found a higher risk of autoimmune hepatitis (AIH) in infants, children, and adolescents and recommended administering COVID-19 vaccination.<sup>50</sup>

However, antivaccine activists and conspiracy believers disseminated misinformation that COVID-19 vaccines were the cause of the rise in hepatitis cases in children.<sup>51,52</sup> Their evidence was quite peripheral and almost irrelevant to AIH child cases, and included a case report of an adult patient

who contracted acute hepatitis twice, following the first and second doses of Pfizer’s BNT162b2 mRNA vaccine.<sup>53</sup> While that particular case seems to have been associated with the vaccine, it was incorrect to use it to link pediatric cases with the vaccine. Unfortunately, many people unwittingly linked the outbreak of acute hepatitis (liver inflammation) in children with COVID-19 vaccination,<sup>51</sup> potentially increasing popular reluctance to COVID-19 vaccine.<sup>54</sup>

In early 2021, a case report described the development of AIH in a 35-year-old woman following the administration of the Pfizer-BioNTech BNT162b2 mRNA vaccine.<sup>55</sup> Subsequently, several case reports and case series illustrated AIH cases following COVID-19 vaccination using different platforms, including mRNA (Pfizer-BioNTech BNT162b2 and Moderna mRNA-1273) and adenoviral vector (ChAdOx1 nCoV-19 Oxford-AstraZeneca) vaccines. These cases occurred in people with and without pre-existing medical conditions.<sup>56</sup> Another piece of evidence came from a case of AIH with a rapid onset of liver injury after the first dose of the Moderna vaccine. It led to acute, severe AIH after re-exposure during the second dose.<sup>57</sup> Later, Boettler et al,<sup>53</sup> hypothesized the involvement of SARS-CoV-2-spike-specific CD8<sup>+</sup> T cells in mediating the development of vaccine-associated AIH in an adult, based on a single case report.

A pre-pandemic systematic review and meta-analysis conducted in 2019 estimated the worldwide incidence and prevalence of AIH at approximately 1.37 and 17.4 per 100 000 people, respectively.<sup>58</sup> Owing to this low background incidence, the risk of AIH did not feature in the clinical trials of various COVID-19 vaccines. After more than two years of vaccinations of hundreds of millions of people worldwide, a population-based pharmacovigilance analysis by Chen et al,<sup>59</sup> found that from December 2020 to March 2022, only 53 reports of AIH following COVID-19 vaccination were reported to the Centers for Disease Control and Prevention COVID Data Tracker and the Vaccines Adverse Event Reporting System. The study concluded that COVID-19 vaccine did not increase the risk of AIH.<sup>59</sup>

There was no evidence of genuine medical researchers withholding information regarding any potential adverse events following vaccination. This was shown by many studies and case reports in the literature that had documented cases of AIH that



occurred after COVID-19 vaccination. It is also the nature of science to question all conclusions. Thus, phase four post-marketing surveillance is needed to determine whether COVID-19 vaccines truly increase the incidence of any diseases, including AIH, above their previous background levels. As previously mentioned, Chen et al,<sup>59</sup> showed that the COVID-19 vaccines did not increase the risk of AIH.

In every scientific field including medicine, rigorous scrutiny, and continuous refinement are driven by the persistent skepticism of the scientific community, driven by a strong peer review process. This ensures that results and conclusions are always reexamined and corrected as required.

This contrasts with the approach of perpetrators of conspiracy theories whose claims tend to lack the support of proper research, peer review, or verifiable evidence.<sup>41</sup> A frequent tactic of anti-vaccine activists is 'skewing the science'. On the one side, they would reject scientific evidence showing the benefits of vaccination. They also seek to destroy the legitimacy and scientific integrity of organizations such as WHO, academic scientists, research organizations, pharmaceutical companies, and governments whose findings and recommendations do not match their beliefs systems and agenda.

Anti-vaccine activists also incorrectly promote any scientific evidence or hypothesis, that could be exploited to boost their ideas.<sup>42</sup> A single adult case report by Boettler et al,<sup>53</sup> was exaggerated and misrepresented to lend credence to their allegation that the COVID-19 vaccine causes AIH in children.

Based on the currently available clinical, epidemiological, and laboratory data, the leading hypothesis of the AIH outbreak in children is the infectious origin of an unidentified viral pathogen and immune dysregulation during acute hepatitis infection in children.<sup>60</sup> Most importantly, those antivaccine activists covered up the fact that most affected children were unvaccinated against COVID-19 since they were not yet eligible.<sup>51</sup> Thus, it is unscientific to blame COVID-19 vaccines as potential triggers for the upsurge in severe pediatric hepatitis cases.

The pediatric population is the target for COVID-19 vaccinations to acquire herd immunity against SARS-CoV-2. Conspiracy theories and misinformation about COVID-19 vaccines, together with the hepatitis outbreak, pose a threat to international efforts to combat the COVID-19

pandemic. Of note, conspiracy theories are more likely to emerge during public health crises. We must also remember that even though the worst part of the pandemic is over, COVID-19 cases are still emerging and vaccination is also being given. As per WHO's latest COVID-19 Vaccination Insights Report for the first quarter of 2024, globally, 9.8 million individuals received a dose of COVID-19 vaccine.<sup>61</sup> Health experts and government agencies should dispel fears regarding the COVID-19 vaccine in children by providing the public with clear and evidence-based facts.

### *The impact of COVID-19 pandemic on vaccine hesitancy*

Vaccine hesitancy has influenced the preventive measures to control COVID-19 cases through mass vaccination. Due to massive misinformation and propaganda of conspiracy theories during the pandemic,<sup>54</sup> it is interesting to gather information on how it may influence vaccine hesitancy during and after the COVID-19 pandemic, not only to COVID-19 vaccines, but have generalized to other childhood vaccines.<sup>12</sup> Analyses of Google searches showed that searches for common anti-vaccine terms such as 'mercury' and 'autism' significantly increased.<sup>62</sup> Another evidence for this growing problem is a marked increase in scientific articles on vaccine hesitancy since the beginning of the COVID-19 pandemic.<sup>63</sup>

This is of particular concern as most vaccines are administered in early childhood. A meta-analysis of 12 published studies showed that the pooled prevalence of hesitation towards childhood immunization throughout the COVID-19 pandemic was 18.5%.<sup>64</sup> A 2022 survey among 310 American parents with children aged 0–17 years, found a rising hesitancy to vaccinate their children.<sup>65</sup> A significant minority of parents now believed that vaccines were less safe (11%), less important (12%), and less effective (13%) since the start of the COVID-19 pandemic.<sup>65</sup> Not unexpectedly, parents who were not vaccinated against COVID-19 held significantly more negative beliefs than those vaccinated. In areas with poor COVID-19 immunization coverage, there was a greater prevalence of the perception that childhood vaccinations were less effective (17%), and 16% of parents had relatively less trust in health advice from the government (17%), health professionals (12%), and pharmaceutical firms (16%).<sup>65</sup>

Three important factors that influence vaccine hesitancy are religiosity, ethnicity, and income level. A 2024 scoping review analyzed 14 studies that compared religiosity with vaccine hesitancy and found that one's religious beliefs and religiosity were significant predictors of vaccine hesitancy.<sup>66</sup> The influence of ethnicity and income was revealed by a survey conducted among 252 American adults with children.<sup>67</sup> It was found that during the COVID-19 pandemic, there was a small but significant rise in hesitancy towards vaccinating children. The hesitancy was higher among participants with lower household incomes and those belonging to Hispanic and African American ethnicities.<sup>67</sup> The above findings suggested that negative beliefs about childhood vaccination increased during the COVID-19 pandemic and were further influenced by parental religiosity, income, and ethnicity.

However, the above factors are subject to major variations between countries. For example, a study conducted in Saudi Arabia revealed that during the peak COVID-19 pandemic in 2021, 47.3% of 2501 Saudi caregivers expressed their intention to vaccinate their children against influenza, up from 29.8% in the previous year.<sup>68</sup> A meta-analysis study also supported the considerable rise in parental enthusiasm to vaccinate their children against the seasonal influenza virus.<sup>64</sup>

Parents' desire to vaccinate their children also depends on their perception of the severity of COVID-19. For instance, when an online poll was done during the COVID-19 pandemic, parents' intentions to give their children an influenza vaccination increased by 15%. Fear that their child would get COVID-19 was a factor influencing their decision to switch to vaccinations.<sup>69</sup>

### ***Strategies to address future vaccine hesitancy***

As early as 2014, the SAGE Working Group recommended a multipronged approach, customized for each target population.<sup>10</sup> Strategies to improve vaccine uptake should include increasing public awareness about vaccination, providing rural and marginalized areas better access to vaccination, involving religious and community leaders, and making vaccines mandatory.<sup>10</sup>

In 2021, Razai et al.<sup>70</sup> proposed a five C strategy comprising confidence, complacency, convenience, communication, and context, to overcome vaccine hesitancy. The first three C's were incorporated

from the SAGE Working Group's strategy.<sup>10</sup> 'Communication' refers to clear information about vaccines delivered to the community, and 'context' refers to the need to be mindful of the socio-demography of the target group.<sup>70</sup>

Enlisting vaccine ambassadors could be a strategy to increase awareness, like in San Francisco, which used the 'Motivate, Vaccinate, Activate' campaign to promote the COVID-19 vaccine.<sup>71</sup> A study in low- and middle-income countries found that most participants would trust healthcare providers to decide on getting the COVID-19 vaccine, indicating that in these countries, health professionals have a crucial role in helping people overcome vaccine hesitancy.<sup>72</sup>

One of the examples of improving vaccine access is the recommendation to provide COVID-19 vaccines in jails. Yet, collaboration with health authorities was highly required.<sup>73</sup> India successfully included religious authorities to increase COVID-19 vaccine awareness and acceptance. The fact that brochures were distributed in local languages to various communities helped counter vaccine misinformation. Among Indian Muslims, the local imams facilitated educational sessions on vaccination in mosques after Friday prayers.<sup>74</sup>

Another way that governments could ensure the vaccination of adults and children is by mandating compulsory COVID-19 vaccine certification to improve vaccine uptake.<sup>75</sup> However, this may be resisted in countries that place a high premium on individualism and personal freedom. A Twitter survey conducted after the announcement of mandatory COVID-19 vaccination in Austria in 2021 found that 45.7% of 2545 respondents did not support that policy.<sup>76</sup> Similarly, a study in the French population also revealed that 41.9% of 3056 participants refused the mandatory COVID-19 vaccination.<sup>77</sup>

Social media can be used by the government to interact with the public and disseminate COVID-19 information.<sup>78</sup> Effective communication and counteraction to anti-vaccine sentiment should be conducted. For example, social media companies made efforts not to foster anti-vaccination in 2019. Ads were deleted on YouTube videos of anti-vaccine movements; thus, the account did not earn money. When searching for vaccine-related information on Twitter in the USA and the UK, the National Health Service and the Department of Health and

Human Services came up as the top results. Any anti-vaccination profiles were not suggested by Facebook.<sup>43</sup>

Although social media companies address misinformation and provide accurate vaccine information, their actions are still falling short of what is needed. Misinformation remains widespread, undermining public confidence, and obstructing vaccination initiatives.<sup>79,80</sup> To address these issues, social media platforms must strengthen their strategies. This includes refining algorithms to more effectively identify and curb false information, collaborating with public health agencies to disseminate accurate content, and improving transparency in their content moderation. Additionally, investing in educational campaigns to highlight the importance of vaccines and promoting community engagement to foster informed discussions are essential.<sup>81</sup> By implementing these measures, social media companies can play a crucial role in combating vaccine hesitancy and safeguarding public health.

### *The root of the problem*

The increase in vaccine hesitancy is not a standalone problem, but part of a growing trend of public to distrust science and scientific expertise. A 2021 survey by Pew Research Center revealed a substantial decline in the U.S. adults who expressed ‘a great deal of confidence’ in medical scientists—29% compared to 40% in the previous year.<sup>82</sup> The survey also indicated a 10% fall (29% in 2021 vs. 39% in 2020) in the respondents’ belief that scientists acted in the public interest. Such mistrust extends to other scientific fields, one of which is the widespread and persistent climate change denial despite clear evidence and scientific consensus for human-caused climate change, which has also been ratified most countries of the world as per the Paris Agreement.<sup>83</sup>

The roots of this generalized mistrust may be factors such as information overload, increased trust in similarly thinking peer groups via social media, all of which contribute to cognitive biases and increase them. This suggests that humanity is subjected to an unprecedented information overload that overtaxes our cognitive capacity. The human mind seeks certainty and is uncomfortable with uncertainty. Therefore, many of us seek refuge in groups that share and accentuate our beliefs, hopes, and fears. Our desire to seek refuge from uncertainty increases during periods of crisis.

This is why the popularity of conspiracy theories—which tend to offer simplistic information that satisfies our emotional needs—multiply during times of public health crises and other emergencies.<sup>54</sup> Joining conspiracy theory groups offers us the comfort of believing in a set of few ‘certainties’ and causes us to distrust contrary data.

This represents a complex long-term challenge, of which vaccine hesitancy is only a symptom. This can only be tackled by long-term strategies. Among the potential remedies is to reform the education system from the current learning strategies based on memorizing facts to one focused on developing critical thinking and logical reasoning from childhood.<sup>84</sup> If all countries could adopt this shift in public education, within a decade or two, humanity would be in a better position to handle the future tsunamis of misinformation of all types, including those against vaccinations.

## CONCLUSION

Vaccine hesitancy has been increasing worldwide during the COVID-19 pandemic, which impacted the rate of COVID-19 vaccine acceptance. The massive spread of misinformation and conspiracy theories were responsible for this. Even though the worst of the pandemic is behind us, vaccine hesitancy has become more generalized. The increased skepticism about all vaccinations is likely to impact children the most as most vaccinations are administered during early childhood. Some previously tamed pediatric infectious diseases are making a comeback in some societies, for example, polio.

Conspiracy theories are more likely to emerge during times of public health crises. Thus, health experts and government agencies should provide clear and succinct facts about vaccination. HCWs should be well-educated on addressing vaccine hesitancy in the general population. Social media can be used to interact with the public and disseminate vaccine information. Social media platforms must strengthen their strategies to address misinformation. Developing critical thinking and logical reasoning from childhood are also important aspects of tackling vaccine hesitancy. Thus, addressing vaccine hesitancy requires a multipronged approach. A strong and continuous collaboration between the government, international and national health authorities, academia, HCWs, and the community



is highly required to maintain successful vaccination programs after the COVID-19 pandemic.

#### Disclosure

The authors declared no conflicts of interest. No funding was received for this study.

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