COVID-19: The Pseudo-Environment and the Need for a Paradigm Change

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As the COVID-19 pandemic was gripping the world, attention coalesced around the cautiously optimistic prospect that at least one of the >150 vaccine candidates at various stages of development as of July 2020 would be successful.[1,2] As of late 2021, four vaccines were authorized by the European Medicines Agency (EMA), and three of them were authorized by the US Food and Drug Administration (FDA) for emergency use, the first of which received full FDA approval in August 2021 and was approved for children over five years old in November 2021.[3-6] The effectiveness and safety of these vaccines set the path for changing the course of the pandemic, bringing a glimpse of hope for the first time in many months.

We owe the development of these highly effective vaccines to the convergence of multiple favorable factors. These include advances in molecular epidemiology, biotechnology, and cooperation across international research networks, which enabled the first genomic information of SARS-CoV-2 to become available on January 10, 2020, just 54 days after the first declared case;[7-9] massive contributions from private and public funds that fueled research and development;[10-12] the establishment of several corporate and public health partnerships;[13-15] and the use of a broad range of technology platforms to evaluate vaccines.[16] Several steps in vaccine research and development were staggered and/or run in parallel, even before the outcome of the previous step was confirmed;[17-19] knowledge from studies on previous coronaviruses[17,20] and on mRNA-based vaccine platforms[21,22] was incorporated into the current vaccine initiatives; in several countries, public funds supported financial risk-taking;[10,19] and phase I and II clinical trials recruited more volunteers than previous clinical trials, helping speed the transition to phase III studies in large, diverse, multinational cohorts.[10,19]

However, the effectiveness of a vaccine depends not only on its efficacy and safety, but also on its widespread uptake in the population. The way out of the pandemic was muddied by a dizzying deluge of conspiracy theories about the virus, the disease, and the vaccines. This maelstrom of misinformation and disinformation polarized and politicized society and continues to do so at the expense of human suffering and lost lives. Some conspiracy theories claim that the virus and the disease do not exist,[23] that they were created by healthcare professionals or the industry to commercialize vaccines[23,24] or cleanse the population,[25] that the virus is a population control scheme,[26] that 5G is the cause of COVID-19 or facilitates its spread,[27,28] that a cure exists but the world's elites[25] or pharmaceutical companies[29] are not sharing it, or that vitamin C and garlic, or mixing a sodium chlorite solution with citric acid to generate a chlorine dioxide solution, could help.[30] Marginally evaluated "repurposed" drugs, such as hydroxychloroquine and veterinary ivermectin, were hyped through social media and celebrity endorsements.[31-33] Masks as a safety measure were politicized[34-36] and became a controversial topic in the US during the pandemic,[37] even though many studies have demonstrated their effectiveness against the

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transmission of several respiratory viruses,[38-42] including SARS-CoV-2.[43,44] Conversely, in several countries in Asia mask wearing has become long accepted as a strategy to prevent exposure to airborne pathogens[45,46] and air pollution[47,48] and as a way to show solidarity, civic responsibility, allegiance to science, and common sense.[47]

An analysis of several large nationally representative study surveys across 13 countries indicates that the percentage of the population that intends to be vaccinated against COVID-19 has declined as the pandemic has progressed.[49] Exposure to faulty information and distorted, then amplified concerns about vaccine safety emerged both in the US[50] and the UK[51] as contributing factors. The good news is that as of early November 2021, >4 billion people, or >51% of the world's population, has received at least one COVID-19 vaccine dose.[52] The concerning situation is that rather rapidly waning immunity has required booster shots such that *fully vaccinated* may not be equivalent to *strongly protected*. Herd immunity is an elusive and now receding goal with the strong evidence that vaccinated people can acquire, amplify, and transmit the virus, albeit to a lesser extent.[53-57] Large populations, most notably across Africa[58-60] and historically underserved communities,[61,62] have little or no practical access to the vaccines today. Political as well as social adoption of the COVID-19 vaccines was neither an easy nor a straightforward task, and the path forward does not seem to become any easier.

The rampant spread of misinformation flourished even more once the vaccine-related conspiracy theories emerged and blended into the already circulating misinformation about the virus and the disease. Arguments that the pandemic is a ploy to force everyone to be vaccinated,[28] that the vaccine is a plan to control and track the population with embedded microchips[28] or to alter people's genomes,[63,64] or claims that people will become infertile[64-66] or will have miscarriages[67-70] spread on social media and were shared extensively. An intricate interplay across these multiple layers of misinformation was, to a great extent, driven by trolls and social media chatter, which in 2020 was dominated by the COVID-19 pandemic.[71,72] The ubiquitous platforms were co-opted, weaponized, and promulgated by individuals and groups sowing discord,[72] and the political and media operatives endlessly repeating and amplifying false narratives set the stage for *a perfect storm*.[73] The pandemic polarized societies to a greater extent than many other events in recent history, provoked tribalism, and created a world in which *the line between fact and opinion fades*.[74] Disinformation has resulted in health-care personnel and scientists being bullied, vilified, threatened, assaulted, and attacked.[75-79]

Anti-vaccination rhetoric is not new; it has existed ever since vaccines were first introduced,[80,81] despite vaccination being one of the most successful developments in science and medicine. In Edward Jenner's times, cartoons claimed that vaccination would cause people to develop cow horns and tails.[82] Vaccine-related misinformation delayed the eradication of preventable infectious diseases and sometimes led to their reemergence, undermining public health.[83-87]

For infectious diseases with long-lasting immunity, such as measles and pertussis, pockets of nonmedical (religious and philosophical) exemption to vaccination overlap geographically with pockets of disease[88-90] and increase the risks to individuals and the population.[90-95] Clusters of nonmedical exemption to school immunization in Michigan revealed a geographic overlap with clusters of reported cases of pertussis.[92] In a study on children in Colorado, those with vaccination exemptions were >22 times more likely to acquire measles and 5.9 times more likely to acquire pertussis than those who were vaccinated.[96] A population-based retrospective cohort study found that people claiming religious and/or philosophical exemption from the measles vaccine were 35 times more likely to contract measles than vaccinated people,[97] and several studies reported that those with nonmedical exemptions and those who refused vaccines place vaccinated individuals at risk as well.[91,98,99] Understandably, in 2019 the World Health Organization identified vaccine hesitancy as one of the top ten global health threats.[100]

Due to the relatively short-lived humoral immune response to SARS-CoV-2, the public health damage caused by vaccination hesitancy/refusal and misinformation is more immediate, and more impactful, than in the case of many other infectious diseases. In the COVID-19 pandemic, the realistic scenario that unvaccinated individuals may re-infect vaccinated individuals with waning immunity threatens our hopes to forge a way out of the pandemic. Immunity to seasonal coronaviruses lasts from 80 days to a few years[101] and natural reinfection with the same strain is possible 12 months after infection.[102] During the 2002-2004 SARS outbreak, protective antibody titers to SARS-CoV-1 persisted for one to two years.[103-105] The duration of humoral immunity to SARS-CoV-2 is not well understood but appears to be short-lived after natural infection,[106-108] an important aspect when developing public health interventions. In severe, mild, and asymptomatic SARS-CoV-2, the antibody half-life was 69, 87, and 31 days, respectively.[109] Misconceptions about waning antibody levels in the months following vaccination were one of the factors that led skeptics to question the purposes of vaccination, which are primarily the reduction of severe illness,[110,111] hospitalization,[112,113] and death.[114,115] With an uneven distribution of vaccines and their delayed rollout to children, the emergence of new viral variants, the short-lived humoral immune response, and the spread of misinformation, the focus on the likelihood to achieve herd immunity and on its potential impact subsided as compared to the early days of the pandemic.

Misinformation about COVID-19 vaccines started to spread even before a vaccine was developed.[116] Even five to ten minutes of contact with vaccination-critical web sites are sufficient to exert a negative impact on the intention to vaccinate.[117] As the impact of vaccination refusal and misinformation has changed in the COVID-19 era, the strategy for how to best combat misinformation, and at the same time provide accurate and reliable knowledge, has also shifted, and remains an ongoing challenge. In a world where falsehoods have been spreading *faster and farther*[118] than accurate information, we are navigating wildly uncharted territories.

In the wake of the pandemic, the *political polarization* described in several countries,[119-124] particularly on social networks,[125] is evident as a major barrier to pandemic mitigation.[121,126,127] Understanding and countering how polarization is driven on social networks[125,126] are emerging as a critical focus if the pandemic is to be controlled and ended. Social media, including Facebook,[128,129] Flickr, Instagram,[130] and Twitter[71,131] facilitate *echo chambers*, in which individuals seek, select, and interpret information that conforms to their beliefs.[132-134] Echo chambers, where people only *hear their own voice*,[135] reinforce self-justification. Generating and distributing a safe and effective vaccine in record time is no longer sufficient to combat this, and probably future pandemics. Instead, building a framework that integrates biomedical sciences, engineering, and biotechnology, with insights from social, political, and communication sciences, is indispensable. This framework needs to place a major emphasis on trusted health practitioners, well informed community leaders, social networks, and promotion of digital health literacy.[136-138]

In his book *Public Opinion*,[139] Walter Lippmann talks about the *pseudo-environment*, the world that is inserted between individuals and their environment. The genesis, dynamics, and consequences of this *pseudo-environment* are very relevant in the pandemic that we are navigating. Lippmann points out that the images and views that we generate are acted upon by individuals and groups of individuals, and they collectively shape public opinion. However, public opinions can often mislead as we interact with the surrounding world, and they create what he insightfully calls the *pictures in our heads*. Individuals act in response to the *pseudo-environment*, but the consequences of their actions operate in the *real environment*. This may be a common denominator to misinformation occurring in many domains of life, whether generated by fabrication, distortion, or omission.

When misinformation pertains to medical and scientific facts, the dangers to individual and collective wellbeing and to public health are immediate, far-reaching, long-lasting, and difficult to reverse, if possible at all. This should be one of the most memorable lessons that the current pandemic has conferred.

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References

1. Liu C, Zhou Q, Li Y, et al. Research and development on therapeutic agents and vaccines for COVID-19 and related human coronavirus diseases. ACS Cent Sci. 2020;6:315-31. https://doi.org/10.1021/acscentsci.0c00272
2. Kaur SP, Gupta V. COVID-19 vaccine: a comprehensive status report. Virus Res. 2020;288:198114. https://doi.org/10.1016/j.virusres.2020.198114
3. Tanzi E, Genovese C, Tettamanzi M, Fappani C, Raviglione MC, Amendola A. COVID-19 vaccines: evidence, challenges and the future. J Prev Med Hyg. 2021;62:E18-E29.
4. Lythgoe MP, Middleton P. Comparison of COVID-19 vaccine approvals at the US Food and Drug Administration, European Medicines Agency, and Health Canada. JAMA Netw Open. 2021;4:e2114531. https://doi.org/10.1001/jamanetworkopen.2021.14531
5. Food and Drug Administration. 2021. FDA approves first COVID-19 vaccine. Accessed on: 13 October 2021. Available at: https://www.fda.gov/news-events/press-announcements/fda-approves-first-covid-19-vaccine.
6. Woodworth KR, Moulia D, Collins JP, et al. The Advisory Committee on Immunization Practices' interim recommendation for use of Pfizer-BioNTech COVID-19 vaccine in children aged 5-11 years - United States, November 2021. MMWR Morb Mortal Wkly Rep. 2021;70:1579-83. https://doi.org/10.15585/mmwr.mm7045e1
7. Tregoning JS, Brown ES, Cheeseman HM, et al. Vaccines for COVID-19. Clin Exp Immunol. 2020;202:162-92. https://doi.org/10.1111/cei.13517
8. Yi Y, Lagniton PNP, Ye S, Li E, Xu RH. COVID-19: what has been learned and to be learned about the novel coronavirus disease. Int J Biol Sci. 2020;16:1753-66. https://doi.org/10.7150/ijbs.45134
9. Bhat EA, Khan J, Sajjad N, et al. SARS-CoV-2: insight in genome structure, pathogenesis and viral receptor binding analysis - an updated review. Int Immunopharmacol. 2021;95:107493. https://doi.org/10.1016/j.intimp.2021.107493
10. Deplanque D, Launay O. Efficacy of COVID-19 vaccines: from clinical trials to real life. Therapie. 2021;76:277-83. https://doi.org/10.1016/j.therap.2021.05.004
11. Kuter BJ, Offit PA, Poland GA. The development of COVID-19 vaccines in the United States: why and how so fast? Vaccine. 2021;39:2491-5. https://doi.org/10.1016/j.vaccine.2021.03.077
12. Forman R, Anderson M, Jit M, Mossialos E. Ensuring access and affordability through COVID-19 vaccine research and development investments: a proposal for the options market for vaccines. Vaccine. 2020;38:6075-7. https://doi.org/10.1016/j.vaccine.2020.07.068
13. Lurie N, Keusch GT, Dzau VJ. Urgent lessons from COVID 19: why the world needs a standing, coordinated system and sustainable financing for global research and development. Lancet. 2021;397:1229-36. https://doi.org/10.1016/S0140-6736(21)00503-1
14. Chaudhary N, Weissman D, Whitehead KA. mRNA vaccines for infectious diseases: principles, delivery and clinical translation. Nat Rev Drug Discov. 2021:20:817-38. https://doi.org/10.1038/s41573-021-00283-5
15. Baden LR, El Sahly HM, Essink B, et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. N Engl J Med. 2021;384:403-16. https://doi.org/10.1056/NEJMoa2035389
16. Thanh Le T, Andreadakis Z, Kumar A, et al. The COVID-19 vaccine development landscape. Nat Rev Drug Discov. 2020;19:305-6. https://doi.org/10.1038/d41573-020-00073-5
17. Hanney SR, Wooding S, Sussex J, Grant J. From COVID-19 research to vaccine application: why might it take 17 months not 17 years and what are the wider lessons? Health Res Policy Syst. 2020;18:61. https://doi.org/10.1186/s12961-020-00571-3
18. Lurie N, Saville M, Hatchett R, Halton J. Developing COVID-19 vaccines at pandemic speed. N Engl J Med. 2020;382:1969-73. https://doi.org/10.1056/NEJMp2005630
19. Krammer F. SARS-CoV-2 vaccines in development. Nature. 2020;586:516-27. https://doi.org/10.1038/s41586-020-2798-3
20. Hodgson J. The pandemic pipeline. Nat Biotechnol. 2020;38:523-32. https://doi.org/10.1038/d41587-020-00005-z
21. Damase TR, Sukhovershin R, Boada C, Taraballi F, Pettigrew RI, Cooke JP. The limitless future of RNA

therapeutics. Front Bioeng Biotechnol. 2021;9:628137. https://doi.org/10.3389/fbioe.2021.628137
22. Maruggi G, Zhang C, Li J, Ulmer JB, Yu D. mRNA as a transformative technology for vaccine development to control infectious diseases. Mol Ther. 2019;27:757-72. https://doi.org/10.1016/j.ymthe.2019.01.020
23. Hakim MS. SARS-CoV-2, Covid-19, and the debunking of conspiracy theories. Rev Med Virol. 2021;31:e2222. https://doi.org/10.1002/rmv.2222
24. Ullah I, Khan KS, Tahir MJ, Ahmed A, Harapan H. Myths and conspiracy theories on vaccines and COVID-19: potential effect on global vaccine refusals. Vacunas. 2021;22:93-7. https://doi.org/10.1016/j.vacun.2021.01.001
25. Bernard FO, Akaito JA, Joseph I, David KB. COVID-19: the trends of conspiracy theories vs facts. Pan Afr Med J. 2020;35:147. https://doi.org/10.11604/pamj.supp.2020.35.2.25536
26. Islam MS, Sarkar T, Khan SH, et al. COVID-19-related infodemic and its impact on public health: a global social media analysis. Am J Trop Med Hyg. 2020;103:1621-9. https://doi.org/10.4269/ajtmh.20-0812
27. Ahmed W, Vidal-Alaball J, Downing J, López Seguí F. COVID-19 and the 5G conspiracy theory: social network analysis of Twitter data. J Med Internet Res. 2020;22:e19458. https://doi.org/10.2196/19458
28. Wirawan GBS, Mahardani PNTY, Cahyani MRK, Laksmi NLPSP, Januraga PP. Conspiracy beliefs and trust as determinants of COVID-19 vaccine acceptance in Bali, Indonesia: cross-sectional study. Pers Individ Dif. 2021;180:110995. https://doi.org/10.1016/j.paid.2021.110995
29. Li HO, Bailey A, Huynh D, Chan J. YouTube as a source of information on COVID-19: a pandemic of misinformation? BMJ Glob Health. 2020;5:e002604. https://doi.org/10.2139/ssrn.3569884
30. Mian A, Khan S. Coronavirus: the spread of misinformation. BMC Med. 2020;18:89. https://doi.org/10.1186/s12916-020-01556-3
31. Merone L, Finlay S. Pandemic and promise: progress towards finding an effective treatment for novel coronavirus 19. Aust N Z J Public Health. 2020;44:437-9. https://doi.org/10.1111/1753-6405.13044
32. Carrion-Alvarez D, Tijerina-Salina PX. Fake news in COVID-19: a perspective. Health Promot Perspect. 2020;10:290-1. https://doi.org/10.34172/hpp.2020.44
33. Machiels JD, Ter Avest M, Ten Oever J, Kramers C. [Chloroquine for COVID-19: a hype or not?]. Ned Tijdschr Geneeskd. 2020;164:D5475.
34. Kahane LH. Politicizing the mask: political, economic and demographic factors affecting mask wearing behavior in the USA. East Econ J. 2021:1-21. https://doi.org/10.1057/s41302-020-00186-0
35. Howard MC. Are face masks a partisan issue during the COVID-19 pandemic? Differentiating political ideology and political party affiliation. Int J Psychol. 2021. https://doi.org/10.1002/ijop.12809
36. He L, He C, Reynolds TL, et al. Why do people oppose mask wearing? A comprehensive analysis of U.S. tweets during the COVID-19 pandemic. J Am Med Inform Assoc. 2021;28:1564-73. https://doi.org/10.1093/jamia/ocab047
37. Lang J, Erickson WW, Jing-Schmidt Z. #MaskOn! #MaskOff! Digital polarization of mask-wearing in the United States during COVID-19. PLoS One. 2021;16:e0250817. https://doi.org/10.1371/journal.pone.0250817
38. Leung NHL, Chu DKW, Shiu EYC, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. Nat Med. 2020;26:676-80. https://doi.org/10.1038/s41591-020-0843-2
39. Cowling BJ, Zhou Y, Ip DK, Leung GM, Aiello AE. Face masks to prevent transmission of influenza virus: a systematic review. Epidemiol Infect. 2010;138:449-56. https://doi.org/10.1017/S0950268809991658
40. Bin-Reza F, Lopez Chavarrias V, Nicoll A, Chamberland ME. The use of masks and respirators to prevent transmission of influenza: a systematic review of the scientific evidence. Influenza Other Respir Viruses. 2012;6:257-67. https://doi.org/10.1111/j.1750-2659.2011.00307.x
41. Liang M, Gao L, Cheng C, et al. Efficacy of face mask in preventing respiratory virus transmission: a systematic review and meta-analysis. Travel Med Infect Dis. 2020;36:101751. https://doi.org/10.1016/j.tmaid.2020.101751
42. Brienen NC, Timen A, Wallinga J, van Steenbergen JE, Teunis PF. The effect of mask use on the spread of influenza during a pandemic. Risk Anal. 2010;30:1210-8. https://doi.org/10.1111/j.1539-6924.2010.01428.x
43. Ueki H, Furusawa Y, Iwatsuki-Horimoto K, et al. Effectiveness of face masks in preventing airborne transmission of SARS-CoV-2. mSphere. 2020;5:e00637-20. https://doi.org/10.1128/mSphere.00637-20
44. Mitze T, Kosfeld R, Rode J, Wälde K. Face masks considerably reduce COVID-19 cases in Germany. Proc Natl Acad Sci U S A. 2020;117:32293-301. https://doi.org/10.1073/pnas.2015954117
45. Wang J, Pan L, Tang S, Ji JS, Shi X. Mask use during COVID-19: a risk adjusted strategy. Environ Pollut.

2020;266:115099. https://doi.org/10.1016/j.envpol.2020.115099
46. Panda S, Kaur H, Dandona L, Bhargava B. Face mask - an essential armour in the fight of India against COVID-19. Indian J Med Res. 2021;153:233-7.
47. Tsang PM, Prost A. Boundaries of solidarity: a meta-ethnography of mask use during past epidemics to inform SARS-CoV-2 suppression. BMJ Glob Health. 2021;6:e004068. https://doi.org/10.1136/bmjgh-2020-004068
48. Burgess A, Horii M. Risk, ritual and health responsibilisation: Japan's 'safety blanket' of surgical face mask-wearing. Sociol Health Illn. 2012;34:1184-98. https://doi.org/10.1111/j.1467-9566.2012.01466.x
49. Robinson E, Jones A, Lesser I, Daly M. International estimates of intended uptake and refusal of COVID-19 vaccines: a rapid systematic review and meta-analysis of large nationally representative samples. Vaccine. 2021;39:2024-34. https://doi.org/10.1016/j.vaccine.2021.02.005
50. Daly M, Robinson E. Willingness to vaccinate against COVID-19 in the U.S.: representative longitudinal evidence from April to October 2020. Am J Prev Med. 2021;60:766-73. https://doi.org/10.1016/j.amepre.2021.01.008
51. Paul E, Steptoe A, Fancourt D. Attitudes towards vaccines and intention to vaccinate against COVID-19: implications for public health communications. Lancet Reg Health Eur. 2021;1:100012. https://doi.org/10.1016/j.lanepe.2020.100012
52. Holder J. 2021. Tracking coronavirus vaccinations around the world. November 4, 2021. Accessed on: 5 November 2021. Available at: https://www.nytimes.com/interactive/2021/world/covid-vaccinations-tracker.html.
53. Brett TS, Rohani P. Transmission dynamics reveal the impracticality of COVID-19 herd immunity strategies. Proc Natl Acad Sci U S A. 2020;117:25897-903. https://doi.org/10.1073/pnas.2008087117
54. Bleier BS, Ramanathan M Jr, Lane AP. COVID-19 vaccines may not prevent nasal SARS-CoV-2 infection and asymptomatic transmission. Otolaryngol Head Neck Surg. 2021;164:305-7. https://doi.org/10.1177/0194599820982633
55. Schiavone M, Gasperetti A, Mitacchione G, Viecca M, Forleo GB. Response to: COVID-19 re-infection. Vaccinated individuals as a potential source of transmission. Eur J Clin Invest. 2021;51:e13544. https://doi.org/10.1111/eci.13544
56. Harder T, Koch J, Vygen-Bonnet S, et al. Efficacy and effectiveness of COVID-19 vaccines against SARS-CoV-2 infection: interim results of a living systematic review, 1 January to 14 May 2021. Euro Surveill. 2021;26:2100563. https://doi.org/10.2807/1560-7917.ES.2021.26.28.2100563
57. Aschwanden C. Five reasons why COVID herd immunity is probably impossible. Nature. 2021;591:520-2. https://doi.org/10.1038/d41586-021-00728-2
58. Nachega JB, Sam-Agudu NA, Masekela R, et al. Addressing challenges to rolling out COVID-19 vaccines in African countries. Lancet Glob Health. 2021;9:e746-8. https://doi.org/10.1016/S2214-109X(21)00097-8
59. Massinga Loembé M, Nkengasong JN. COVID-19 vaccine access in Africa: global distribution, vaccine platforms, and challenges ahead. Immunity. 2021;54:1353-62. https://doi.org/10.1016/j.immuni.2021.06.017
60. Jerving S. The long road ahead for COVID-19 vaccination in Africa. Lancet. 2021;398:827-8. https://doi.org/10.1016/S0140-6736(21)01967-X
61. Pattin AJ. Disparities in the use of immunization services among underserved minority patient populations and the role of pharmacy technicians: a review. J Pharm Technol. 2017;33:171-6. https://doi.org/10.1177/8755122517717533
62. Bazan IS, Akgün KM. COVID-19 Healthcare inequity: lessons learned from annual influenza vaccination rates to mitigate COVID-19 vaccine disparities. Yale J Biol Med. 2021;94:509-15.
63. Hotez P, Batista C, Ergonul O, et al. Correcting COVID-19 vaccine misinformation: Lancet Commission on COVID-19 Vaccines and Therapeutics Task Force Members. EClinicalMedicine. 2021;33:100780. https://doi.org/10.1016/j.eclinm.2021.100780
64. Islam MS, Kamal AM, Kabir A, et al. COVID-19 vaccine rumors and conspiracy theories: the need for cognitive inoculation against misinformation to improve vaccine adherence. PLoS One. 2021;16:e0251605. https://doi.org/10.1371/journal.pone.0251605
65. Loomba S, de Figueiredo A, Piatek SJ, de Graaf K, Larson HJ. Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. Nat Hum Behav. 2021;5:337-48. https://doi.org/10.1038/s41562-021-01056-1
66. Markert UR, Szekeres-Bartho J, Schleußner E. Adverse effects on female fertility from vaccination against COVID-19 unlikely. J Reprod Immunol. 2021;148:103428. https://doi.org/10.1016/j.jri.2021.103428
67. Male V. Are COVID-19 vaccines safe in pregnancy? Nat Rev Immunol. 2021;21:200-1.

https://doi.org/10.1038/s41577-021-00525-y
68. Kharbanda EO, Haapala J, DeSilva M, et al. Spontaneous abortion following COVID-19 vaccination during pregnancy. JAMA. 2021;326:1629-31. https://doi.org/10.1001/jama.2021.15494
69. Schraer R. 2021. Covid vaccine: fertility and miscarriage claims fact-checked. Accessed on: 8 October 2021. Available at: https://www.bbc.com/news/health-57552527.
70. Moodley J, Khaliq OP, Mkhize PZ. Misrepresentation about vaccines that are scaring women. Afr J Prim Health Care Fam Med. 2021;13:e1-e2. https://doi.org/10.4102/phcfm.v13i1.2953
71. Jiang J, Ren X, Ferrara E. Social media polarization and echo chambers in the context of COVID-19: case study. JMIRx Med. 2021;2:e29570. https://doi.org/10.2196/29570
72. 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;108:1378-84. https://doi.org/10.2105/AJPH.2018.304567
73. Cichocka A. To counter conspiracy theories, boost well-being. Nature. 2020;587:177. https://doi.org/10.1038/d41586-020-03130-6
74. Parmet WE, Paul J. COVID-19: the first posttruth pandemic. Am J Public Health. 2020;110:945-6. https://doi.org/10.2105/AJPH.2020.305721
75. McKay D, Heisler M, Mishori R, Catton H, Kloiber O. Attacks against health-care personnel must stop, especially as the world fights COVID-19. Lancet. 2020;395:1743-5. https://doi.org/10.1016/S0140-6736(20)31191-0
76. Larkin H. Navigating attacks against health care workers in the COVID-19 Era. JAMA. 2021;325:1822-4. https://doi.org/10.1001/jama.2021.2701
77. Dye TD, Alcantara L, Siddiqi S, et al. Risk of COVID-19-related bullying, harassment and stigma among healthcare workers: an analytical cross-sectional global study. BMJ Open. 2020;10:e046620. https://doi.org/10.1136/bmjopen-2020-046620
78. Nogrady B. 'I hope you die': how the COVID pandemic unleashed attacks on scientists. Nature. 2021;598:250-3. https://doi.org/10.1038/d41586-021-02741-x
79. Devi S. COVID-19 exacerbates violence against health workers. Lancet. 2020;396:658. https://doi.org/10.1016/S0140-6736(20)31858-4
80. Swingle CA. How do we approach anti-vaccination attitudes? Mo Med. 2018;115:180-1.
81. Poland GA, Jacobson RM. The age-old struggle against the antivaccinationists. N Engl J Med. 2011;364:97-9. https://doi.org/10.1056/NEJMp1010594
82. Henderson DA. Edward Jenner's vaccine. Public Health Rep. 1997;112:116-21.
83. Centers for Disease Control and Prevention (CDC). Resurgence of wild poliovirus type 1 transmission and consequences of importation--21 countries, 2002-2005. MMWR Morb Mortal Wkly Rep. 2006;55:145-50.
84. Warraich HJ. Religious opposition to polio vaccination. Emerg Infect Dis. 2009;15:978. https://doi.org/10.3201/eid1506.090087
85. Kapp C. Surge in polio spreads alarm in northern Nigeria. Rumours about vaccine safety in Muslim-run states threaten WHO's eradication programme. Lancet. 2003;362:1631-2. https://doi.org/10.1016/S0140-6736(03)14826-X
86. Clements CJ, Greenough P, Shull D. How vaccine safety can become political--the example of polio in Nigeria. Curr Drug Saf. 2006;1:117-9. https://doi.org/10.2174/157488606775252575
87. Kaufmann JR, Feldbaum H. Diplomacy and the polio immunization boycott in Northern Nigeria. Health Aff (Millwood). 2009;28:1091-101. https://doi.org/10.1377/hlthaff.28.4.1091
88. Zipfel CM, Garnier R, Kuney MC, Bansal S. The landscape of childhood vaccine exemptions in the United States. Sci Data. 2020;7:401. https://doi.org/10.1038/s41597-020-00742-5
89. Paquette ET. In the wake of a pandemic: revisiting school approaches to nonmedical exemptions to mandatory vaccination in the US. J Pediatr. 2021;231:17-23. https://doi.org/10.1016/j.jpeds.2021.01.022
90. Bednarczyk RA, King AR, Lahijani A, Omer SB. Current landscape of nonmedical vaccination exemptions in the United States: impact of policy changes. Expert Rev Vaccines. 2019;18:175-90. https://doi.org/10.1080/14760584.2019.1562344
91. Wang E, Clymer J, Davis-Hayes C, Buttenheim A. Nonmedical exemptions from school immunization requirements: a systematic review. Am J Public Health. 2014;104:e62-84. https://doi.org/10.2105/AJPH.2014.302190
92. Omer SB, Enger KS, Moulton LH, Halsey NA, Stokley S, Salmon DA. Geographic clustering of nonmedical exemptions to school immunization requirements and associations with geographic clustering of pertussis. Am J Epidemiol. 2008;168:1389-96. https://doi.org/10.1093/aje/kwn263

93. Omer SB, Pan WK, Halsey NA, et al. Nonmedical exemptions to school immunization requirements: secular trends and association of state policies with pertussis incidence. JAMA. 2006;296:1757-63. https://doi.org/10.1001/jama.296.14.1757
94. Centers for Disease Control and Prevention (CDC). Imported measles case associated with nonmedical vaccine exemption--Iowa, March 2004. MMWR Morb Mortal Wkly Rep. 2004;53:244-6.
95. Phadke VK, Bednarczyk RA, Salmon DA, Omer SB. Association between vaccine refusal and vaccine-preventable diseases in the United States: a review of measles and pertussis. JAMA. 2016;315:1149-58. https://doi.org/10.1001/jama.2016.1353
96. Feikin DR, Lezotte DC, Hamman RF, Salmon DA, Chen RT, Hoffman RE. Individual and community risks of measles and pertussis associated with personal exemptions to immunization. JAMA. 2000;284:3145-50. https://doi.org/10.1001/jama.284.24.3145
97. Salmon DA, Haber M, Gangarosa EJ, Phillips L, Smith NJ, Chen RT. Health consequences of religious and philosophical exemptions from immunization laws: individual and societal risk of measles. JAMA. 1999;282:47-53.https://doi.org/10.1001/jama.282.1.47
98. Centers for Disease Control and Prevention (CDC). Measles outbreak--Southwestern Utah, 1996. MMWR Morb Mortal Wkly Rep. 1997;46:766-9.
99. Arora KS, Morris J, Jacobs AJ. Refusal of vaccination: a test to balance societal and individual interests. J Clin Ethics. 2018;29:206-16.
100. Megget K. Even COVID-19 can't kill the anti-vaccination movement. BMJ. 2020;369:m2184. https://doi.org/10.1136/bmj.m2184
101. Poland GA, Ovsyannikova IG, Kennedy RB. SARS-CoV-2 immunity: review and applications to phase 3 vaccine candidates. Lancet. 2020;396:1595-606. https://doi.org/10.1016/S0140-6736(20)32137-1
102. Edridge AWD, Kaczorowska J, Hoste ACR, et al. Seasonal coronavirus protective immunity is short-lasting. Nat Med. 2020;26:1691-3. https://doi.org/10.1038/s41591-020-1083-1
103. Cao WC, Liu W, Zhang PH, Zhang F, Richardus JH. Disappearance of antibodies to SARS-associated coronavirus after recovery. N Engl J Med. 2007;357:1162-3. https://doi.org/10.1056/NEJMc070348
104. Wu LP, Wang NC, Chang YH, et al. Duration of antibody responses after severe acute respiratory syndrome. Emerg Infect Dis. 2007;13:1562-4. https://doi.org/10.3201/eid1310.070576
105. Mo H, Zeng G, Ren X, et al. Longitudinal profile of antibodies against SARS-coronavirus in SARS patients and their clinical significance. Respirology. 2006;11:49-53. https://doi.org/10.1111/j.1440-1843.2006.00783.x
106. Seow J, Graham C, Merrick B, et al. Longitudinal observation and decline of neutralizing antibody responses in the three months following SARS-CoV-2 infection in humans. Nature Nat Microbiol. 2020;5:1598-1607. https://doi.org/10.1038/s41564-020-00813-8
107. Ibarrondo FJ, Fulcher JA, Goodman-Meza D, et al. Rapid decay of anti-SARS-CoV-2 antibodies in persons with mild COVID-19. N Engl J Med. 2020;383:1085-7. https://doi.org/10.1056/NEJMc2025179
108. Long QX, Tang XJ, Shi QL, et al. Clinical and immunological assessment of asymptomatic SARS-CoV-2 infections. Nat Med. 2020;26:1200-4. https://doi.org/10.1038/s41591-020-0965-6
109. Lau EHY, Tsang OTY, Hui DSC, et al. Neutralizing antibody titres in SARS-CoV-2 infections. Nat Commun. 2021;12:63. https://doi.org/10.1038/s41467-020-20247-4
110. Lopez Bernal J, Andrews N, Gower C, et al. Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on COVID-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study. BMJ. 2021;373:n1088. https://doi.org/10.1136/bmj.n1088
111. Scobie HM, Johnson AG, Suthar AB, et al. Monitoring incidence of COVID-19 cases, hospitalizations, and deaths, by vaccination status - 13 U.S. jurisdictions, April 4-July 17, 2021. MMWR Morb Mortal Wkly Rep. 2021;70:1284-90. https://doi.org/10.15585/mmwr.mm7037e1
112. Thompson MG, Stenehjem E, Grannis S, et al. Effectiveness of COVID-19 vaccines in ambulatory and inpatient care settings. N Engl J Med. 2021;385:1355-71. https://doi.org/10.1056/NEJMoa2110362
113. Cevik M, Grubaugh ND, Iwasaki A, Openshaw P. COVID-19 vaccines: keeping pace with SARS-CoV-2 variants. Cell. 2021;184:5077-81. https://doi.org/10.1016/j.cell.2021.09.010
114. Tavilani A, Abbasi E, Kian Ara F, Darini A, Asefy Z. COVID-19 vaccines: current evidence and considerations. Metabol Open. 2021;12:100124. https://doi.org/10.1016/j.metop.2021.100124
115. Hodgson SH, Mansatta K, Mallett G, Harris V, Emary KRW, Pollard AJ. What defines an efficacious COVID-19 vaccine? A review of the challenges

assessing the clinical efficacy of vaccines against SARS-CoV-2. Lancet Infect Dis. 2021;21:e26-e35. https://doi.org/10.1016/S1473-3099(20)30773-8
116. Zhang S. 2020. We don't even have a COVID-19 vaccine, and yet the conspiracies are here. Accessed on: 17 November 2021. Available at: https://www.theatlantic.com/science/archive/2020/05/covid-19-vaccine-skeptics-conspiracies/611998/.
117. Betsch C, Renkewitz F, Betsch T, Ulshöfer C. The influence of vaccine-critical websites on perceiving vaccination risks. J Health Psychol. 2010;15:446-55. https://doi.org/10.1177/1359105309353647
118. Sylvia Chou WY, Gaysynsky A, Cappella JN. Where we go from here: health misinformation on social media. Am J Public Health. 2020;110:S273-s5. https://doi.org/10.2105/AJPH.2020.305905
119. Singh M. Politics and the pandemic. In: Hidalgo J, Rodríguez-Vega G, Pérez-Fernández J, eds. COVID-19 pandemic. Elsevier; 2022. pp: 137-46. https://doi.org/10.1016/B978-0-323-82860-4.00011-2
120. Bruine de Bruin W, Saw HW, Goldman DP. Political polarization in US residents' COVID-19 risk perceptions, policy preferences, and protective behaviors. J Risk Uncertain. 2020:1-18. https://doi.org/10.1007/s11166-020-09336-3
121. Jiang J, Chen E, Lerman K, Ferrara E. Political polarization drives online conversations about COVID-19 in the United States. Hum Behav Emerg Technol. 2020:10.1002/hbe2.202. https://doi.org/10.1002/hbe2.202
122. Arabaghatta Basavaraj K, Saikia P, Varughese A, Semetko HA, Kumar A. The COVID-19-social identity-digital media nexus in India: polarization and blame. Polit Psychol. 2021:10.1111/pops.12774. https://doi.org/10.1111/pops.12774
123. Havey NF. Partisan public health: how does political ideology influence support for COVID-19 related misinformation? J Comput Soc Sci. 2020:1-24. https://doi.org/10.1007/s42001-020-00089-2
124. Jungkunz S. Political polarization during the COVID-19 pandemic. Front Polit Sci. 2021;3. https://doi.org/10.3389/fpos.2021.622512
125. Hong I, Rutherford A, Cebrian M. Social mobilization and polarization can create volatility in COVID-19 pandemic control. Appl Netw Sci. 2021;6:11. https://doi.org/10.1007/s41109-021-00356-9
126. Chipidza W. The effect of toxicity on COVID-19 news network formation in political subcommunities on Reddit: an affiliation network approach. Int J Inf Manage. 2021;61:102397. https://doi.org/10.1016/j.ijinfomgt.2021.102397
127. Chen HF, Karim SA. Relationship between political partisanship and COVID-19 deaths: future implications for public health. J Public Health (Oxf). 2021:fdab136. https://doi.org/10.1093/pubmed/fdab136
128. Del Vicario M, Vivaldo G, Bessi A, et al. Echo chambers: emotional contagion and group polarization on Facebook. Sci Rep. 2016;6:37825. https://doi.org/10.1038/srep37825
129. Cinelli M, De Francisci Morales G, Galeazzi A, Quattrociocchi W, Starnini M. The echo chamber effect on social media. Proc Natl Acad Sci U S A. 2021;118:e2023301118. https://doi.org/10.1073/pnas.2023301118
130. Fung IC, Blankenship EB, Ahweyevu JO, et al. Public health implications of image-based social media: a systematic review of Instagram, Pinterest, Tumblr, and Flickr. Perm J. 2020;24:18.307.
131. Wang D, Qian Y. Echo chamber effect in rumor rebuttal discussions about COVID-19 in China: social media content and network analysis study. J Med Internet Res. 2021;23:e27009. https://doi.org/10.2196/27009
132. Van Bavel JJ, Pereira A. The partisan brain: an identity-based model of political belief. Trends Cogn Sci. 2018;22:213-24. https://doi.org/10.1016/j.tics.2018.01.004
133. Brugnoli E, Cinelli M, Quattrociocchi W, Scala A. Recursive patterns in online echo chambers. Sci Rep. 2019;9:20118. https://doi.org/10.1038/s41598-019-56191-7
134. Allahverdyan AE, Galstyan A. Opinion dynamics with confirmation bias. PLoS One. 2014;9:e99557. https://doi.org/10.1371/journal.pone.0099557
135. Villa G, Pasi G, Viviani M. Echo chamber detection and analysis: a topology- and content-based approach in the COVID-19 scenario. Soc Netw Anal Min. 2021;11:78. https://doi.org/10.1007/s13278-021-00779-3
136. Patil U, Kostareva U, Hadley M, et al. Health literacy, digital health literacy, and COVID-19 pandemic attitudes and behaviors in U.S. college students: implications for interventions. Int J Environ Res Public Health. 2021;18:3301. https://doi.org/10.3390/ijerph18063301
137. Levin-Zamir D. Communication, health literacy and a systems approach for mitigating the COVID-19 pandemic: the case for massive vaccine roll-out in Israel. J Health Commun. 2020;25:816-8. https://doi.org/10.1080/10810730.2021.1884773

138. Duong TV, Lin CY, Chen SC, et al. Oxford COVID-19 vaccine hesitancy in school principals: impacts of gender, well-being, and coronavirus-related health literacy. Vaccines (Basel). 2021;9:985. https://doi.org/10.3390/vaccines9090985

139. Lippmann W. Public Opinion. Free Press Paperbacks. New York: Simon & Schuster. 1997.

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