Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Review article

Myths and conspiracy theories on vaccines and COVID-19: Potential effect on global vaccine refusals

I. Ullah\textsuperscript{a,b,c}, K.S. Khan\textsuperscript{d}, M.J. Tahir\textsuperscript{e,f}, A. Ahmed\textsuperscript{g}, H. Harapan\textsuperscript{h,i,j,*}

\textsuperscript{a} Kabir Medical College, Gandhara University, Peshawar 25000, Pakistan
\textsuperscript{b} Undergraduate Research Organization, Dhaka 1342, Bangladesh
\textsuperscript{c} Naseer Teaching Hospital, Peshawar 25000, Pakistan
\textsuperscript{d} Dow Medical College, Dow University of Health Sciences, Karachi 74200, Pakistan
\textsuperscript{e} Ameer-ud-Din Medical College, Affiliated with University of Health and Sciences, Lahore 54000, Pakistan
\textsuperscript{f} Lahore General Hospital, Lahore 54000, Pakistan
\textsuperscript{g} School of Pharmacy, Monash University, Bandar Sunway 47500, Malaysia
\textsuperscript{h} Medical Research Unit, School of Medicine, Indonesia
\textsuperscript{i} Tropical Diseases Centre, School of Medicine, Indonesia
\textsuperscript{j} Department of Microbiology, School of Medicine, Banda Aceh 23111, Indonesia

\begin{abstract}
The current coronavirus disease 2019 (COVID-19) pandemic is one of the international crises and researchers are working collaboratively to develop a safe and effective COVID-19 vaccine. The World Health Organization recognizes vaccine hesitancy as the world’s top threat to public health safety, particularly in low middle-income countries. Vaccine hesitancy can be due to a lack of knowledge, false religious beliefs, or anti-vaccine misinformation. The current situation regarding anti-vaccine beliefs is pointing towards dreadful outcomes. It raises the concern that will people believe and accept the new COVID-19 vaccines despite all anti-vaccine movements and COVID-19-related myths and conspiracy theories. This review discusses the possible detrimental impacts of myths and conspiracy theories related to COVID-19 and vaccine on COVID-19 vaccine refusals as well as other vaccine programs.
\end{abstract}

© 2021 Elsevier España, S.L.U. All rights reserved.

\begin{resumen}
Mitos, teorías conspiratorias y COVID-19: efecto potencial en los rechazos globales a la vacunación
\end{resumen}

La pandemia actual de COVID-19 (enfermedad por coronavirus de 2019) es una crisis internacional y los investigadores están trabajando conjuntamente para desarrollar una vacuna efectiva contra ella. La Organización Mundial de la Salud reconoce la renuencia a la
Mitos
Conspiración
Anti-vacunación

Background

The spread of coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome-related coronavirus 2 (SARS-CoV-2), has resulted in an unprecedented humanitarian and economic crisis.1,2 SARS-CoV-2 is an enveloped and positive-sense single-stranded RNA virus and a member of the genus Betacoronavirus.2 There are no current specific treatments for COVID-193-5 but more than 100 vaccine candidates have been in the development pipeline and researchers have worked collaboratively to develop the vaccines against COVID-19.6 However, this international effort could be hindered by vaccine hesitancy, which is an internationally prevalent phenomenon.7 Vaccines have been approved as a highly efficacious and cost-effective community health measure for disease prevention since it could reduce the mortality and morbidity rate of the diseases.8 However, the vaccination program is still assumed as an unsafe and unnecessary by many individuals both in developed and developing countries.9 For example in the US, due to inadequate vaccine coverage, measles outbreaks occurred in California between 2014–2015 and 5–10% of the population had anti-vaccination beliefs.10 A study in 2012 based on population surveys or registers from the US, European Union, New Zealand, and Australia, found that 20–30% individuals were categorized as being hesitant concerning about vaccination.11 Lack of knowledge and confidence in vaccination are now considered to be the greatest threat to the success of vaccination programs.9 Vaccine hesitancy may decrease the vaccine coverage and increase the risk of vaccine-preventable diseases and the outbreaks.9

Vaccine acceptance and hesitancy determinants

Vaccine acceptance and hesitancy depend upon the beliefs in vaccination, its safety, the trust placed in the system that delivers the vaccines, health issues, fear of side effects, and lack of a healthcare workers recommendation.12,13 Beliefs regarding the benefit and effectiveness of vaccines, wariness of the motives behind, the influence of family especially parents’ attitude and conversation with friends on vaccination decisions are also influence the vaccine acceptance and hesitancy.12 A study conducted in Indonesia found that 15% out of total respondents concerned about the safety and efficacy of the vaccine and therefore showed hesitancy towards pediatric vaccination.13 Different social, cultural, and political views also play important role in decision making in vaccination.9 In addition, lack of knowledge about “who, where, and when” one should be vaccinated and self-estimated sufficiency of information about vaccination or satisfaction are frequently associated with vaccination decisions.5 Fear of needles and pain after vaccine injection is also documented as one of the greatest opponents of vaccination.14

Social media and vaccination

Media have played an immense role in keeping vaccination scares alive, even in the era of strong evidence of the fortification and effectiveness of vaccines.15 Different types of facts about vaccines conveyed via media have a gigantic impression on vaccine hesitancy.16 Controversies on vaccine safety, that circulate vigorously in news headlines, talk shows, and popular articles also upsurge the vaccine hesitancy and anti-vaccine behavior in the community.9 In addition to traditional media, internet has also provided other podiums for various social media18 to multiple anti-vaccine vocalists through which they reach the general population to diffuse the wrong or negative messages.19 Anti-vaccination contents on internet have widely broadcast the rumors, myths, and inaccurate beliefs regarding vaccines and they have detrimental impacts on vaccine uptake.20 A study conducted in Atlanta at the time of the 2009 National Immunization Survey have shown that individuals who delayed or refused the vaccines are more likely to have searched for vaccine information on the internet.21

Role of negative beliefs and faith

Vaccination refusal is also frequently related to philosophical beliefs and moral faiths regarding health and immunity making “natural” superior over “artificial” medicines.22 It has also been associated with strong religious beliefs. Anti-vaccine propaganda in 2011 intensified that vaccine is western intrigue to sterilize Muslim girls and that vaccine is made up of gelatin from porcine which is haram and therefore forbidden in Islam.23 It is also cogitating as a partial fact that some vaccines are produced using porcine-based enzymes which is intolerable for some Islamic scholars, particularly concerning
the haram notion. Another untrue fact become unacceptable for some scholars is aborted to produce vaccine especially virus-based-vaccines that require culturing of the virus in specific human cells. However these are fringe views and in almost every major religious authority has denounced such use of their religion and vaccination does not violate the religions because vaccination preserves health and duty to community.

Concerns on overloading the child’s immune system by giving several vaccines at the same time are beyond the pale in many backward areas. In fact, combination vaccines also mean fewer injections which are a good step to reduce parental anxiety and hassle on the child. In addition, vague information regarding both vaccine safety and the process contributing to vaccine licensure and enormous problems for public health clinicians, policymakers, and for patients as well.

Myths and conspiracy theories on COVID-19 and their consequences

In some places, people do not believe in COVID-19 existence, the virus is intangible and not very concrete and for some individuals, it is really hard to accept that a “flu-like illness” could be life-threatening. Some believe that COVID-19 is a business for health care workers (HCWs) and doctors are diagnosing every fever as COVID-19 for their benefits. Ironically, in some places, people attacked HCWs in the hospitals for not handing over the dead body immediately to the family. The claim that COVID-19 is a pre-planned project to cover the Bill Gates trackable microwchip conspiracy was also raised. With that, the storm of “infodemic”, conveyed by social media is of great concern.

Myth about the origin of virus was also emerged and people also believe that government is providing false number of COVID-19 cases because a large number of cases will get more profit and donation. Many people also believe that it is from God as a punishment, the 5G technology directly transmits the virus and weaken the human immunity, and some consider that the virus is a bio-warfare weapon. In addition, the video “Plandemic” that shows that COVID-19 pandemic is a conspiracy of pharmaceutical companies to sell their products also have become viral through social media platforms adding the list of conspiracy theories. All these raise the question: will people believe the COVID-19 vaccine and will they accept it? In addition, the most unwanted domino effect is it might decrease childhood immunization practices due to trends of conspiracy theory. Therefore, well-designed mass campaign might need to be implemented in the community to reduce the COVID-19 related myths.

It should be noted that the core of anti-vaccine beliefs is a conspiracy theory that vaccines do not work and/or are actively harmful because cause autism, autoimmune disease, infertility in teenaged girls or others. Opposition against vaccines manifests not only in theological arguments but also object to them for political and legal reasons. Anti-vaccine activists such as Robert F. Kennedy, Andrew Wakefield, Del Matthew Bigtree, Jennifer McCarthy Wahlberg have kicked into overdrive and public health experts fear that their messaging could further harm the response to the pandemic. One of the hallmarks of the anti-vaccine movement is the sense of selfishness and lack of concern for other people’s health. Anti-vaccine activists like to talk about rights and freedom but what they really want is freedom without consequences. Vaccine critics, for example, have long championed the false claim that vaccines cause autism, and that the US Centers for Disease Control and Prevention (CDC) has tried to cover up that information and they are now rebranding themselves as advocates of medical freedom. Therefore, scientific data and messages on vaccination, such as information from the WHO and the CDC, are relevant to the discussion on immunization. Therefore, increasing the knowledge and understanding of the people is important to reduce the detrimental effects of anti-vaccine movement in community.

COVID-19 vaccine challenges

Enormous efforts have been made to invent an effective vaccine that might be the best measure to end the current COVID-19 pandemic. However, the effectiveness of the vaccine not only will depend on its efficacy but also the uptake (i.e., the acceptance) of the vaccine in population. In Australia, among 4,362 surveyed adults 85.8% would accept the COVID-19 vaccine while in the US only 67% out of 672 surveyed participants would accept the vaccine if it is recommended. A survey in 19 countries that included 13,426 people found that 71.5% of participants would be very or somewhat likely to take the COVID-19 vaccine, ranged from almost 90% (in China) to less than 55% (in Russia). In Iran, 73.2% out of 1,480 respondents stated they would accept an approved COVID-19 vaccine if it were to become available. Many factors influence the vaccine acceptance including the vaccine efficacy. In Indonesia, a study found that 93.3% out of 1,359 surveyed respondents would like to be vaccinated with the vaccine that has a 95% efficacy but it dropped to 67.0% when the vaccine has 50% efficacy only. Studies found that inadequate health literacy, lower education level, concerned about vaccine efficacy and safety, low trust in government, and low income were associated with COVID-19 vaccine hesitancy.

The implementation of the vaccination program will be an important factor for COVID-19 vaccination success and this depends fully on community acceptance of the vaccine. What if large parts of the general population refuse to take the vaccine, once it is available? Therefore, a campaign at mass level is needed to increase the public knowledge and awareness of COVID-19 to reduce COVID-19 vaccine refusal and ultimately to increase the vaccine coverage.

A way forward

Community education is one of the primary aspects that needs to be enhanced in a timely manner and the foundation for COVID-19 vaccine acceptance for the public should be plotted beforehand in order to ensure COVID-19 vaccination success. In addition, the government and health community should follow certain aspects to promote the upcoming
COVID-19 vaccine uptake. First, the COVID-19 vaccination program should be rigorously delivered to the public via social media and HCWs should raise voice about the potential obstacles to vaccine hesitancy using etymological and ethnical competent messages.\textsuperscript{41} Second, public health NGOs and public figures (celebrities and religious leaders) should develop a forceful COVID-19 vaccine educational and awareness campaign and transfer COVID-19 vaccine knowledge focusing on misinformation.\textsuperscript{41} Third, frontline HCWs should recommend COVID-19 vaccination as soon as it becomes available. Finally, the government should make sure the vaccine will be enough in the market to the public as soon as the trial is completed and its efficacy and safety ensured. In addition, subsidy from the government is one of success key to achieve high COVID-19 vaccine coverage since the acceptance is price sensitive.\textsuperscript{42,43}

**Conclusion**

Social, cultural, and political contexts play the vital role in decision making regarding vaccine acceptance and refusal. Anti-vaccine controversies concerning vaccine safety are vigorously circulating by social media via different platforms, upsurge the vaccine hesitancy among community members. The anti-vaccine behaviors among community due to misinformation might potentially hamper the COVID-19 vaccine program and to have domino effects on other vaccination program. Therefore, efforts to diminish the myths and conspiracy theories on COVID-19 and vaccines that involving multi-sectorial elements are needed to increase the acceptance of COVID-19 vaccine when it is available in the near future.

**Ethical approval**

Not required.

**Authors’ contributions**

I.U. and K.S. conceived the idea, I.U., K.S., M.J.T., H.H. & A.A. wrote the initial manuscript, and H.H. and A.A. revised and reviewed the final manuscript. All authors have read and agreed to the published version of the manuscript.

**Funding**

No funding sources.

**Conflict of interests**

No potential conflict of interest was reported by the authors.

**Acknowledgment**

We would like to thanks HT Editorial Service Indonesia for the assistance during the manuscript preparation.

**REFERENCES**

1. Rodriguez-Morales AJ, Cardona-Ospina JA, Gutierrez-Ocampo E, Villamizar-Pena R, Holguin-Rivera Y, Escalera-Antezaña JP, et al. Clinical, laboratory and imaging features of COVID-19: a systematic review and meta-analysis. Travel Med Infect Dis. 2020;34:101623.
2. Harapan H, Itoh N, Yufika A, Winardi W, Keamg S, Te H, et al. Coronavirus disease 2019 (COVID-19): a literature review. J Infect Public Health. 2020;13:667–73.
3. Frediansyah A, Nainu F, Dhamad K, Mudatsir M, Harapan H. Remdesivir and its antiviral activity against COVID-19: a systematic review. Clin Epidemiol Glob Health. 2021;9:123–7.
4. Frediansyah A, Tiwari R, Sharan K, Dhamak K, Harapan H. Antivirals for COVID-19: a critical review. Clin Epidemiol Glob Health. 2021;9:90–8.
5. Sharan K, Tiwari R, Iqbal Yatoo M, Patel SK, Natesan S, Dhama J, et al. Antibody-based immunotherapeutics and use of convalescent plasma to counter COVID-19: advances and prospects. Expert Opin Biol Ther. 2020;20:1033–46.
6. Thanh Le T, Arendakakis Z, Kumar A, Gomez Roman R, Tollefsen S, Saville M, et al. The COVID-19 vaccine development landscape. Nat Rev Drug Discov. 2020;19:305–6.
7. Palamenghi L, Barello S, Boccia S, Graffigna G. Mistrust in biomedical research and vaccine hesitancy: the forefront challenge in the battle against COVID-19 in Italy. Eur J Epidemiol. 2020;5–8, http://dx.doi.org/10.1007/s10654-020-00677 [Epub ahead of print].
8. Thunstrom L, Ashworth M, Finnoff D, Newbold S. Hesitancy towards a COVID-19 vaccine and prospects for herd immunity; 2020. Available at: SSRN 3593098.
9. Dubé E, Laberge C, Guay M, Bramadat P, Roy R, Bettinger JA. Vaccine hesitancy: an overview. Hum Vacc Immunother. 2013;9:1763–73.
10. Pananos AD, Bury TM, Wang C, Schonfeld J, Mohanty SP, Nyhan B, et al. Critical dynamics in population vaccinating behavior. Proc Natl Acad Sci USA. 2017;114:13762–7.
11. Leask J, Kinnersley P, Jackson C, Cheater F, Bedford H, Rowles G. Communicating with parents about vaccination: a framework for health professionals. BMC Pediatrics. 2012;12:154.
12. Nichter M. Vaccinations in the Third World: a consideration of community demand. Soc Sci Med. 1995;41:617–32.
13. Yufika A, Wagner AL, Nawawi Y, Wahyuniati N, Anwar S, Yusri F, et al. Parents’ hesitancy towards vaccination in Indonesia: a cross-sectional study in Indonesia. Vaccine. 2020;38:2592–9.
14. Taddio A, Ipp M, Thivakaran S, Jamal A, Parikh C, Smart S, et al. Survey of the prevalence of immunization non-compliance due to needle fears in children and adults. Vaccine. 2012;30:4807–12.
15. Smith A, Yarwood J, Salisbury DM. Tracking mothers’ attitudes to MMR immunisation 1996–2006. Vaccine. 2007;25:3996–4002.
16. Larson HJ, Cooper LZ, Eskola J, Katz SL, Ratzan S. Addressing the vaccine confidence gap. Lancet. 2011;378:526–35.
17. Gangarosa EJ, Galazka AM, Wolfe CR, Phillips LM, Miller E, Chen RT, et al. Impact of anti-vaccine movements on pertussis control: the untold story. Lancet. 1998;351:356–61.
18. Wolfe RM, Sharp LK, Lipsky MS. Content and design attributes of antivaccination web sites. JAMA. 2002;287:3245–8.
19. Zimmerman RK, Wolfe RM, Fox DE, Fox JR, Nowalk MP, Troy JA, et al. Vaccine criticism on the world wide web. J Med Internet Res. 2005;7:e17.
20. Kata A. Anti-vaccine activists, Web 2.0, and the postmodern paradigm – an overview of tactics and tropes used online by the anti-vaccination movement. Vaccine. 2012;30:3778–89.
21. Smith PJ, Humiston SG, Marcuse EK, Zhao Z, Dorell CG, Howes C, et al. Parental delay or refusal of vaccine doses, childhood vaccination coverage at 24 months of age, and the Health Belief Model. Public Health Rep. 2011;126:135–46.
22. Streiffland PH. Public doubts about vaccination safety and resistance against vaccination. Health Policy. 2001;55:159–72.
23. Martínez-Bravo M, Stegmann A. In vaccines we trust? The effects of the CIA’s vaccine ruse on immunization in Pakistan 2018. CEMFI Working Paper No. 1713. Available from: https://www.cemfi.es/ftp/wp/1713.pdf [accessed 25.09.20].
24. Bin Abdullah AB. Halal vaccine and the ethical dimension of vaccination programmes. Islam and Civilisational Renewal. 2014;274:1–4.
25. Ali A. Childhood vaccine controversies: the myths, the facts and the uncertainties. Sci Malay. 2016:12.
26. Grabenstein JD. What the world’s religions teach, applied to vaccines and immune globulins. Vaccine. 2013;31:2011–23.
27. Ofrit PA, Quarles J, Gerber MA, Hackett CJ, Marcuse EK, Kollman TR, et al. Addressing parents’ concerns: do multiple vaccines overwhelm or weaken the infant’s immune system? Pediatrics. 2002;109:124–9.
28. DAWN. Mob vandalsise JPMC ward after hospital’s refusal to hand over Covid-19 patient’s body. Available from: https://www.dawn.com/news/1557115 [accessed 15.06.20].
29. SAMAAA. Karachi’s Civil Hospital attacked by mob after COVID-19 patient dies. Available from: https://www.samaa.tv/news/2020/05/karachicivil-hospital-attacked-by-mob-after-covid-19-patient-dies/ [accessed 15.06.20].
30. News B. Coronavirus: Bill Gates ‘microchip’ conspiracy theory and other vaccine claims fact-checked. Available from: https://www.bbc.com/news/52847648 [accessed 15.06.20].
31. Sabah D. COVID-19 myths, conspiracies: Another unfortunate aspect of pandemic. Available from: www.dailysabah.com/opinion/op-ed/covid-19-myths-conspiracies-another-unfortunate-aspect-of-pandemic [accessed 15.06.20].
32. Conversation T. Four experts investigate how the 5G coronavirus conspiracy theory began. Available from: https://theconversation.com/four-experts-investigate-how-the-5g-coronavirus-conspiracy-theory-began-139137 [accessed 25.09.20].
33. DW. How denial and conspiracy theories fuel coronavirus crisis in Pakistan. Available from: www.dw.com/en/how-denial-and-conspiracy-theories-fuel-coronavirus-crisis-in-pakistan/a-53913842 [accessed 25.09.20].
34. Wire T. Fake News, Hiding Data and Profits: How COVID-19 Spun Out of Control in Brazil. Available from: https://thewire.in/health/brazil-jaibolsonaro-covid-19.
35. Dodd RH, Cvejie B, Bonner C, Pickles K, McCaffery KJ. Sydney Health Literacy Lab C-g. Willingness to vaccinate against COVID-19 in Australia. Lancet Infect Dis. 2020, http://dx.doi.org/10.1016/S1473-3099(20)30559-4 [Epub ahead of print].
36. Malik AA, McFadden SM, Elharake J, Omer SB. Determinants of COVID-19 vaccine acceptance in the US. EClinicalMedicine. 2020;26:100495.
37. Lazarus JV, Ratzan SC, Palayew A, Gostin LO, Larson HJ, Rabin K, et al. A global survey of potential acceptance of a COVID-19 vaccine. Nat Med. 2020, http://dx.doi.org/10.1038/s41591-020-1124-9 [Epub ahead of print].
38. Kakemam E, Ghoddooi-Nejad D, Chegini Z, Momeni K, Salehnia H, Hassanipour S, et al. Knowledge, attitudes, and practices among the general population during COVID-19 outbreak in Iran: a national cross-sectional survey. Front Public Health. 2020;8:585302.
39. Rhodes A, Hoq M, Measey MA, Danchin M. Intention to vaccinate against COVID-19 in Australia. Lancet Infect Dis. 2020, http://dx.doi.org/10.1016/S1473-3099(20)30724-6 [Epub ahead of print].
40. Harapan H, Wagner AL, Yufika A, Winardi W, Anwar S, Gan AK, et al. Acceptance of a COVID-19 vaccine in southeast Asia: a cross-sectional study in Indonesia. Front Public Health. 2020;8:381.
41. Fadda M, Albanese E, Suggs LS. When a COVID-19 vaccine is ready, will we all be ready for it? Int J Public Health. 2020;65:711–2.
42. Garcia LY, Cerda AA. Contingent assessment of the COVID-19 vaccine. Vaccine. 2020;38:5424–9.
43. Harapan H, Wagner AL, Yufika A, Winardi W, Anwar S, Gan AK, et al. Willingness-to-pay for a COVID-19 vaccine and its associated determinants in Indonesia. Hum Vaccin Immunother. 2020;16:3074–80.