



Review Article

Global acceptance and hesitancy of COVID-19 vaccination: A narrative review

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Abstract

The coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is a major global health threat to human civilization and has disrupted many aspects of the community around the globe. Vaccination is one of the prominent measures to control the COVID-19 pandemic. More than 120 vaccines have entered human clinical trials and at least 8 vaccines have been fully approved. However, the success of the COVID-19 vaccination programs depends on how the community accepts the vaccines. Despite COVID-19 vaccination having been initiated for a while now, more than 50% of the global population have not been vaccinated. In some low- and middle-income countries (LMICs), the vaccine coverage is less than 20%. Since the decision to accept the new vaccine is complex, understanding the factors underpinning vaccine acceptance is critical. This review aimed to summarize the COVID-19 vaccine acceptance rate around the globe as well as its associated determinants. Information from this study might be important to formulate effective strategies to increase the COVID-19 vaccine coverage, and to be able to achieve herd immunity.

Keywords: COVID-19, COVID-19 vaccine, vaccination, vaccine acceptance, vaccine hesitancy

Introduction

In December 2019, the coronavirus disease 2019 (COVID-19) outbreak started in Wuhan, China. The COVID-19 outbreak was declared as a pandemic by the World Health Organization (WHO) on March 11, 2020 and as of October 9, 2021, there have been more than 236.5 million confirmed cases and more than 4.8 million deaths worldwide [1]. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the causative agent of COVID-19, is closely related to other newly emerging coronaviruses such as severe acute respiratory syndrome (SARS) coronavirus that emerged in 2002-2003, and the Middle East respiratory syndrome (MERS) coronavirus which emerged in 2012 [2]. The SARS-CoV-2 is a single-stranded, positive-sense RNA virus [3]. These viruses contain spike proteins (S-proteins) that bind with angiotensin-converting enzyme 2 (ACE2) receptors present on the surface of human lung epithelial cells [3]. ACE2 receptors are the same receptors utilized by the SARS-CoV [4]. After adhering to the cell



membrane, the virus hijacks the cell machinery, integrating its RNA into the cell's replication cycle, causing its further proliferation in the body and activating host immune responses [3].

The mortality rate of COVID-19 is lower than SARS and MERS and varies among countries. However, COVID-19 is significantly more contagious than SARS and MERS, hence the number of cases skyrocketed and outweighed both MERS and SARS [3]. SARS-CoV-2 is primarily transmitted through respiratory droplets (i.e., coughs, sneezes, and mucus that contain viral particles) [5]. On average, the droplets can travel not more than 2 meters and do not linger in the air [6, 7]. However, under experimental conditions, the SARS-CoV-2 remains viable in aerosols for 3 hours [7]. In addition, the viruses have also been shown to be transmitted through fomites (transmitted through contaminated surfaces) [7]. SARS-CoV-2 could contaminate different surfaces for several hours to up to 3 days depending on their material [7]. The median incubation period of COVID-19 is five days; however, it could be up to two weeks [3]. There is mounting evidence that COVID-19 can be transmitted while the person is asymptomatic, subsequently making it difficult to control and contain the spread [3].

The symptoms experienced by individuals infected by the SARS-CoV-2 include but are not limited to fever, cough, shortness of breath, and fatigue [8, 9]. Patients with severe COVID-19 suffer from acute respiratory distress syndrome (ARDS), multiple organ failure, and death [9]. In the absence of a definitive treatment, one of the best strategies is the vaccine [1] and high vaccination coverage is urgently required to achieve herd immunity against COVID-19. Vaccine development began as soon as the first genome sequence of SARS-CoV-2 was identified and published. Approximately 185 COVID-19 vaccines are in the preclinical stage and 102 have been entered clinical trials [10]. Currently, 31% of the COVID-19 vaccines in clinical development are protein subunits, succeeded by 16% of viral vector (non-replicating), 16% of mRNA and, 16% are made with the inactivated virus [10].

The COVID-19 vaccination programs are only successful when they are highly accepted by the community [11]. However, vaccine acceptance and demand are complicated; it is driven by various context-specific factors, including time, space, and most importantly, perceived behaviors of the community [12, 13]. This review sought to summarize the COVID-19 vaccine acceptance and hesitancy around the globe as well as its associated determinants. With this intent, effective strategies to increase the COVID-19 vaccine coverage and eliminate the current COVID-19 pandemic could be formulated.

COVID-19 vaccine: An update

Type of COVID-19 vaccines

Currently, several COVID-19 vaccines have been approved and multiple vaccine candidates are at the clinical stage of development. The vaccines and vaccine candidates were produced with different approaches. Some vaccine developing companies like Pfizer and Moderna employed synthetic mRNA by encoding the sequence of SARS-CoV-2 S-protein, which is then encapsulated within a lipid nanoparticle to preserve its integrity [14]. Oxford-AstraZeneca, Gamaleya (Sputnik V), Janssen, and CanSino developed the recombinant vaccines based on a DNA sequence encoding the S-protein inserted into the genome of a modified safe adenovirus [15]. The pathogen's genetic material is destroyed by heat, chemicals, or radiation so that they cannot replicate but their presence can still stimulate immunogenicity [15]. Sinopharm, Sinovac, and Bharat Biotech's vaccines were produced by inactivating the SARS-CoV-2 (grown in Vero cells) with β -propiolactone and absorbed onto aluminum hydroxide but keeping all the viral protein intact. Novovax, a recombinant protein subunit vaccine, was developed by using full-length S protein with a mutation at S1/S2 cleavage sites which safely generate an immune response against COVID-19 [16]. Without introducing viable pathogen particles, these subunit vaccines contain a fragment of the pathogen, either a protein (Pro-subunit), a polysaccharide, or a combination of both [17].

Efficacy of vaccines

There is a wide variation in the efficacy and safety of different vaccines. After completion of the phase 3 trial, Moderna showed a 93.2% efficacy in preventing COVID-19 and 98.2% in preventing severe COVID-19 cases in participants aging at least 18 years old, while the efficacy of Moderna on adolescents (12-17 years old) is ongoing phase 2/3 trial of and it was difficult to assess due to low incidence of COVID-19 cases in this population [18, 19]. Meanwhile, the first dose of Sputnik V showed 91.6% (16 of 14964 participants) efficacy, and only 0.3% (45/16427 participants) had serious adverse events [20]. Single-dose of Janssen Ad26.COVS.2 S also has a higher efficacy against severe-critical COVID-19 infection based on phase 3 clinical trial (Efficacy: 76.7% for onset at ≥ 14 days and efficacy 85.4% for onset at ≥ 28 days) [21]. Besides, after the pooling of four randomized controlled trials (RCTs), 80.2% of efficacy was reported for adenovirus vectored covid-19 vaccines, e.g., Oxford-AstraZeneca, Gamaleya (Sputnik V), and CanSino [22]. When individually assessed Astra-Zeneca showed 100% efficacy against hospitalizations, with only 0.9% having serious adverse events after the second dose. The efficacy is higher in the participants who received the second dose ≥ 12 weeks after primary injection (81.3%) when compared to those who received the second dose < 6 weeks after the primary injection (55.1%) [23]. Whilst, according to the interim analysis of phase 3 trial held in Russia, Sputnik was found to be 91.6% effective [24]. In May 2021, the phase 3 trials in the United Arab Emirates (UAE) and Bahrain showed that BBIBP-CorV (Sinopharm) was 78.1% effective against symptomatic cases and 100% against severe cases [25]. Conversely, phase 3 results from Brazil showed a 50.7% efficacy of Sinovac at preventing symptomatic infections; however, efficacy against symptomatic infections increased to 62.3% with an interval of 21 days or more between the doses [26]. Based on phase 3 trials in Turkey, 14 days or more after the second dose, Sinovac vaccine efficacy was 83.5% with only 18.9% adverse events and no fatality [27].

A study among health care personnel in the U.S shows that two doses of mRNA vaccines (Pfizer-BioNTech's BNT162b2 and Moderna's mRNA-1273) were 90% effective against SARS-CoV-2 infections at 14 days after full vaccination with the mRNA vaccines and 80% (≥ 14 days after the first dose but before the second dose) [28, 29]. A study in Israel found that the real-world effectiveness of BNT162b2 at seven days or more after the second dose were 95.3% effective against SARS-CoV-2 infection, 91.5% against asymptomatic SARS-CoV-2 infection, 97.0% against symptomatic COVID-19, 97.2% against COVID-19-related hospitalization, 97.5% against severe or critical COVID-19-related hospitalization, and 96.7% against COVID-19-related death [30]. The estimated BNT162b2 vaccine effectiveness at seven or more days after the second dose among 596,618 persons was 94% against symptomatic COVID-19, 87% against hospitalization, and 92% against severe disease [31].

Safety and adverse events of vaccines

A meta-analysis found that mRNA-based vaccines are associated with the highest number of side effects such as pain, redness, swelling, and induration on injection site as well as systematic adverse events such as fever, arthralgia, myalgia, fatigue, vomiting, and headache [22]. Reports of lymphadenopathy and Bell's palsy were also found in very low frequency of those who received the Pfizer vaccine [32]. Oxford-AstraZeneca vaccine had a good safety profile; however, different serious adverse events such as a case of hemolytic anemia, and three cases of transverse myelitis were observed out of 168 participants in Brazil, South Africa, and UK trials [33]. BBIBP-CorV (Sinopharm) and CoronaVac (Sinovac) in phases 1 and 2 of its clinical trial reported well-tolerated adverse reactions, mainly related to the injection site, including pain, itching, and induration along with systemic side effects such as fever, nausea, and constipation [33-35].

COVID-19 vaccine acceptance

Several studies have been conducted to assess the acceptance of COVID-19 around the globe. In Indonesia, a recent cross-sectional study reported 93% and 67% acceptance rates for two vaccines with 95% and 50% effectiveness, respectively [36]. In the United States, the acceptance

rate ranged between 67% and 69% [11, 37]. In China, a study found that vaccine acceptance was 90.6% in the population of high and medium income [38]. Another study found a 91.3% vaccine acceptance rate in the Chinese population mainly due to the effect of the pandemic on their daily lives coupled with the fear of being infected [39]. Studies conducted in different countries revealed acceptance rates of 69% in Turkey [40], 86% in the UK [40], and between 59%-86.1% in Italy [41, 42]. A global survey in 19 countries (Brazil, Canada, China, Ecuador, France, Germany, India, Italy, Mexico, Nigeria, Poland, Russia, Singapore, South Africa, South Korea, Spain, Sweden, UK, and the US) found that Brazil had the highest acceptance rate (85.3%) while Russia had the lowest (54.8%) [43]. The rates of vaccine acceptance in some countries are presented in **Table 1**.

Several studies have revealed some factors associated with COVID-19 vaccine acceptance. A study found that anxiety, risk perception, government satisfaction, and believing in the natural origin of the virus played a key role in the acceptance of vaccines amongst the population of the UK and Turkey [40]. In Italy, age, gender, and different socioeconomic variables were associated with vaccine acceptance [41, 42]. A global survey in 19 countries found that the pandemic situation in the country (case numbers and mortality per million population) and trust in government had significant influence on vaccine acceptance, which resulted in a 71.5% acceptance rate [43]. A complete list of the factors associated with vaccine acceptance is listed in **Table 1**.

COVID-19 vaccine hesitancy

According to the WHO, vaccine hesitancy is one of the top ten global threats to health [44]. A study found that people hesitant to COVID-19 vaccine belonging to low socioeconomic groups, Asian and black ethnic groups, Muslims, Buddhists, and younger female age groups [45]. Lack of awareness and conflicting beliefs were related to COVID-19 vaccine effectiveness, side effects, and objectives, eventually led to a global package of myths and false beliefs [46-49]. The Understanding Society UK Household Longitudinal survey reported 42.7% of participants indicating future unknown effects as the key reason for hesitancy as well worries about side effects and the lack of trust in vaccines [50]. In addition to the people's concerns, media has been playing a significant role in potentiating vaccine-related myths and controversies through headlines, talk shows, and newspapers; thus, upsurging global hostile conduct towards the COVID-19 vaccine [51].

A study in the UK reported that some of the reasons for vaccine rejection are: concerns on vaccine safety and effectiveness, low perceived risk of COVID-19, had infection with COVID-19, no transparency on vaccine development, efficacy, safety, and lack trust in vaccination, science or healthcare workers [52]. A study in Bangladesh showed that vaccine acceptance was influenced by perceived social norms, perceived safety of COVID-19 vaccine, perceived efficacy, perceived risk and severity of getting COVID-19, and trust in the COVID-19 vaccine itself [53]. Among healthcare workers (HCW) in Pakistan, the reasons for COVID-19 vaccine rejection varied based on gender; females HCW had religious concerns and doubts about vaccine effectiveness, while males HCW rejected the vaccine due to prior COVID-19 infection and the side effects of the vaccine [54].

Furthermore, the haram notion is one of the main reasons for the rejection among Muslims and this has fueled negative religious beliefs on COVID-19 vaccine [55]. The haram notion is further intensified by the anti-vaccine propaganda in 2011, resulting in people believing that vaccine is a western intrigue to sterilize Muslim girls [51]. Moreover, it can also be said that certain myths questioning the existence of COVID-19 are emerging to be one of the causes for the hesitancy towards vaccine acceptance [56]. Subsequently, the belief in such myths can result in the unwillingness of people to get the vaccine, predominantly because according to them COVID-19 is nothing more than normal flu or an illness, and not a life-threatening disease, which requires urgency to be vaccinated.

Table 1. COVID-19 vaccine acceptance rate and its associated factors

Country	Design	Sample	COVID-19 vaccine acceptance rate (%)	Factor associated with acceptance/rejection	Reference
China	Cross - sectional	2,058	91.3	Education City of resident Family income Suspected risk of COVID-19 Impact of the pandemic on daily life Vaccination history	[57]
Indonesia	Cross-sectional	1,359	93.3 (95% efficacy)	Perceived risk Healthcare related job Type of occupation Age	[36]
Indonesia	Cross-sectional	1,359	67.0 (50% efficacy)	Healthcare related job	[36]
United States	Cross - sectional	672	67.0	Education Race Risk perception score	[11]
Saudi Arabia	Cross - sectional	992	64.7	Education Occupation City of resident	[58]
Denmark, France, Germany, Italy, Portugal, the Netherlands, and the UK	Cross - sectional	7664	73.9	Concern about potential side effects	[59]
Chile	Cross-sectional	566	90.6 (Willing to pay vaccine)	Income Education Employment Health system Chronic disease Suspected risk of COVID-19	[38]
Israel	Cross-sectional	1,112	75.0	Gender Age Geographic locations Region of residence Marital status Parenthood Status	[60]
Israel	Cross-sectional	829 (healthcare staffs)	69.5	Gender Age Geographic locations Region of residence Marital status Parenthood status	[60]
United States	Cross-sectional	2,006	69.0	Type of health insurance Underlying medical condition Personal history of COVID-19 diagnosis	[37]

France	Cross-sectional	3,259	77.6	Recommendation from the health care provider Gender Age Health care worker Chronic medical condition Vaccine hesitancy Fears about COVID-19 Consideration at risk of COVID-19	[61]
United Kingdom Turkey	Cross-sectional	1,088 (UK) 3,936 (Turkey)	83.0 (UK) 76.0 (Turkey)	Anxiety Risk perception Government satisfaction Gender Believe in the natural origin of the virus	[40]
Italy	Cross-sectional	735 (College students)	86.1	Age Gender Healthcare and non-healthcare curricula	[41]
Ecuador	Cross-sectional	1,050 Households	85.0	Age Household size Income Gender Education Health insurance Employment status Location of residence Region of residence	[62]
Italy	Cross-sectional	1,004	59.0	Age Gender Smoking status Socio-economic variables	[42]
England	cross-sectional survey and semi-structured interviews	1252 parents and guardians	55.8	Household income Employment Ethnicity	[52]
China, Brazil, South Africa, South Korea, Mexico, United States, India, Spain, Ecuador, United Kingdom, Italy, Canada, Germany, Singapore, Sweden, Nigeria, France, Poland, and Russia	Cross-sectional	13,426	71.5	Age Sex Income Education Cases per million population Mortality per million populations Trust in Government	[43]
Uganda	Cross-sectional	1,067	53.6	Age Sex Education Religion Employment	[63]

Jordan	Cross-sectional	3,100	37.4	Marital status Location of residence Age Sex Received influenza vaccine this year The trusted information source of COVID-19 Concern about COVID-19 as conspiracy The safety of the vaccine	[64]
Libya	Cross-sectional	12,006	79.6	Age Have a family member or friend infected with COVID-19 Have a family member or friends died due to COVID-19	[65]
Germany	Cross-sectional	1,037	57.2	Marital status Having chronic illness Perceptions of becoming infected Perceptions of the severity of the potential long-term effects The efficacy of the COVID-19 vaccine The benefits of vaccination	[66]
Jordan	Cross-sectional	1,144	36.8	Sex Marital status Having children Education Concerns regarding the use of vaccines Lack of trust of COVID-19 vaccine	[67]
US, India, Brazil, Russia, Spain, Argentina, Colombia, UK, Mexico, Peru, South Africa, Italy, Chile, Australia, New Zealand, and the Philippines	Cross-sectional	17,871 (Pregnant women and mothers)	52.0 (pregnant women) 73.4 (mothers)	Age Income Education level Marital status Health insurance Confidence in COVID-19 vaccine safety and efficacy Belief in the importance of vaccines/mass vaccination to their own country Confidence in routine childhood vaccines Trust of public health agencies/health science Compliance to mask guidelines	[68]
Malaysia	Cross-sectional	735 (March 2020) 758 (March 2020)	77 (March 2020) 89 (June 2020)	Gender Race Economic disruptions during pandemic Personal experience with COVID-19 Friends experience with COVID-19 Family members' experience with COVID-19 Media experience of a COVID-19 case	[69]
Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	74.0 (95% vaccine efficacy and 20% side effect)	Country Monthly household income Religion Having comorbidity	[70]

Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	80.1 (75% vaccine efficacy and 5% side effect)	Change of salary as a result of the COVID-19 pandemic	[70]
				Believe or not that social distancing can protect the child or children from COVID-19	
				Believe or not vaccines are important for health	
Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	55.6 (75% vaccine efficacy and 20% side effect)	Believe or not that the new vaccines carry more risks	[70]
				Believe or not that all routine recommended vaccines are beneficial	
				Believe or not that information about vaccines from the government is reliable and trustworthy	
Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	58.3 (50% vaccine efficacy and 5% side effect)	Having flu vaccination during the past 12 months	[70]
				Country	
				Religion	
Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	58.3 (50% vaccine efficacy and 5% side effect)	Monthly household income	[70]
				Vaccines are important for my health	
				Believe or not that the new vaccines carry more risks	
Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	58.3 (50% vaccine efficacy and 5% side effect)	Believe or not that all routine recommended vaccines are beneficial	[70]
				Believe or not that information about vaccines from the government is reliable and trustworthy	
				Having flu vaccination during the past 12 months	
Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	58.3 (50% vaccine efficacy and 5% side effect)	Country	[70]
				Religion	
				Monthly household income	
Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	58.3 (50% vaccine efficacy and 5% side effect)	Believe or not vaccines are important for health	[70]
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Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	58.3 (50% vaccine efficacy and 5% side effect)	Believe or not that information about vaccines from the government is reliable and trustworthy	[70]
				Having flu vaccination during the past 12 months	
				Country	
Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	58.3 (50% vaccine efficacy and 5% side effect)	Religion	[70]
				Monthly household income	
				Believe or not vaccines are important for health	
Bangladesh, India, Iran, Pakistan, Egypt, Nigeria, Sudan, Tunisia, Brazil, and Chile	Cross-sectional	1337	58.3 (50% vaccine efficacy and 5% side effect)	Believe or not that the new vaccines carry more risks	[70]
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				Believe or not that information about vaccines from the government is reliable and trustworthy	
				Having flu vaccination during the past 12 months	

Conclusion

The surge in COVID-19 vaccine hesitancy could possibly remain a crucial barrier in combatting COVID-19 until researchers, health care professionals, and public health educators take vital steps in diminishing myths and anti-vaccine conspiracies circulating throughout social media. Studies are therefore important to develop contextualized advertising and information exchange, which will lead to trust and uptake of COVID-19 vaccine.

Ethics approval

Not required.

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Conflict of interest

The authors declare that they have no competing interests.

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Underlying data

All data underlying the results are available as part of the article and no additional source data are required.

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References

1. WHO. WHO Coronavirus (COVID-19) Dashboard. World Health Organization; 2021. Available from: <https://covid19who.int/> 2021. Accessed; 9 October 2021.
2. Drosten C, Gunther S, Preiser W, *et al.* Identification of a novel coronavirus in patients with severe acute respiratory syndrome. N Engl J Med 2003; 348(20):1967-1976.
3. Atzrodt CL, Maknojia I, McCarthy RDP, *et al.* A Guide to COVID-19: a global pandemic caused by the novel coronavirus SARS-CoV-2. FEBS J 2020; 287(17):3633-3650.
4. Hoffmann M, Kleine-Weber H, Schroeder S, *et al.* SARS-CoV-2 Cell Entry Depends on ACE2 and TMPRSS2 and Is Blocked by a Clinically Proven Protease Inhibitor. Cell 2020; 181(2):271-280
5. Dietz L, Horve PF, Coil DA, *et al.* 2019 novel coronavirus (COVID-19) pandemic: built environment considerations to reduce transmission. mSystems 2020; 5(2):e00245-20.
6. Arias FJ. Are runners more prone to become infected with COVID-19? An approach from the Raindrop Collisional Model. J Sci Sport Exerc 2021; 3(2):167-170.
7. van Doremalen N, Bushmaker T, Morris DH, *et al.* Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. N Engl J Med 2020; 382(16):1564-1567.
8. Harapan H, Itoh N, Yufika A, *et al.* Coronavirus disease 2019 (COVID-19): A literature review. J Infect Public Health 2020; 13(5):667-673.
9. Rodriguez-Morales AJ, Cardona-Ospina JA, Gutierrez-Ocampo E, *et al.* Clinical, laboratory and imaging features of COVID-19: A systematic review and meta-analysis. Travel Med Infect Dis 2020; 34:101623.

10. WHO. Organization WH. COVID-19 vaccine tracker and landscape 2021. Available from: <https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines>. Accessed: 4 June 2021) 2021.
11. Malik AA, McFadden SM, Elharake J, *et al.* Determinants of COVID-19 vaccine acceptance in the US. *EClinicalMedicine* 2020; 26:100495.
12. Larson HJ, Jarrett C, Eckersberger E, *et al.* Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007-2012. *Vaccine* 2014; 32(19):2150-2159.
13. Sallam M. COVID-19 vaccine hesitancy worldwide: a concise systematic review of vaccine acceptance rates. *Vaccines (Basel)* 2021; 9(2):160.
14. van Riel D, de Wit E. Next-generation vaccine platforms for COVID-19. *Nat Mater* 2020; 19(8):810-812.
15. Sanders B, Koldijk M, Schuitemaker H. Inactivated viral vaccines. In: *Vaccine analysis: strategies, principles, and control*. edn.: Springer; 2015: 45-80.
16. Sadarangani M, Marchant A, Kollmann TR. Immunological mechanisms of vaccine-induced protection against COVID-19 in humans. *Nat Rev Immunol* 2021; 21(8):475-484.
17. Kyriakidis NC, Lopez-Cortes A, Gonzalez EV, *et al.* SARS-CoV-2 vaccines strategies: a comprehensive review of phase 3 candidates. *NPJ Vaccines* 2021; 6(1):28.
18. El Sahly HM, Baden LR, Essink B, *et al.* Efficacy of the mRNA-1273 SARS-CoV-2 vaccine at completion of blinded phase. *N Engl J Med* 2021; 385(19):1774-1785.
19. Ali K, Berman G, Zhou H, *et al.* Evaluation of mRNA-1273 SARS-CoV-2 vaccine in adolescents. *N Engl J Med* 2021; 1-11. doi: 10.1056/NEJMoa2109522 (In press).
20. Logunov DY, Dolzhikova IV, Shcheblyakov DV, *et al.* Safety and efficacy of an rAd26 and rAd5 vector-based heterologous prime-boost COVID-19 vaccine: an interim analysis of a randomised controlled phase 3 trial in Russia. *The Lancet* 2021; 397(10275):671-681.
21. Sadoff J, Gray G, Vandebosch A, *et al.* Safety and efficacy of single-dose Ad26.COV2.S Vaccine against Covid-19. *New England Journal of Medicine* 2021; 384(23):2187-2201.
22. Pormohammad A, Zarei M, Ghorbani S, *et al.* Efficacy and safety of COVID-19 Vaccines: a systematic review and meta-analysis of randomized clinical trials. *Vaccines (Basel)* 2021; 9(5):467.
23. Voysey M, Costa Clemens SA, Madhi SA, *et al.* Single-dose administration and the influence of the timing of the booster dose on immunogenicity and efficacy of ChAdOx1 nCoV-19 (AZD1222) vaccine: a pooled analysis of four randomised trials. *Lancet* 2021; 397(10277):881-891.
24. Logunov DY, Dolzhikova IV, Shcheblyakov DV, *et al.* Safety and efficacy of an rAd26 and rAd5 vector-based heterologous prime-boost COVID-19 vaccine: an interim analysis of a randomised controlled phase 3 trial in Russia. *Lancet* 2021; 397(10275):671-681.
25. Al Kaabi N, Zhang Y, Xia S, *et al.* Effect of 2 Inactivated SARS-CoV-2 vaccines on symptomatic COVID-19 Infection in adults: a randomized clinical trial. *JAMA* 2021; 326(1):35-45.
26. Palacios R, Patino EG, de Oliveira Pirelli R, *et al.* Double-blind, randomized, placebo-controlled phase III Clinical trial to evaluate the efficacy and safety of treating healthcare professionals with the adsorbed COVID-19 (Inactivated) Vaccine Manufactured by Sinovac - PROFISCOV: A structured summary of a study protocol for a randomised controlled trial. *Trials* 2020; 21(1):853.
27. Tanriover MD, Doğanay HL, Akova M, *et al.* Efficacy and safety of an inactivated whole-virion SARS-CoV-2 vaccine (CoronaVac): interim results of a double-blind, randomised, placebo-controlled, phase 3 trial in Turkey. *Lancet* 2021; 398(10296):213-222.
28. Thompson MG, Burgess JL, Naleway AL, *et al.* Interim estimates of vaccine effectiveness of BNT162b2 and mRNA-1273 COVID-19 vaccines in preventing SARS-CoV-2 infection among health care personnel, first responders, and other essential and frontline workers - Eight U.S. locations, December 2020-March 2021. *Morb Mortal Wkly Rep* 2021; 70(3):495-500.
29. Ito K, Ohmagari N, Mikami A, *et al.* Major ongoing clinical trials for COVID-19 treatment and studies currently being conducted or scheduled in Japan. *Glob Health Med* 2020; 2(2):96-101.
30. Haas EJ, Angulo FJ, McLaughlin JM, *et al.* Impact and effectiveness of mRNA BNT162b2 vaccine against SARS-CoV-2 infections and COVID-19 cases, hospitalisations, and deaths following a nationwide vaccination campaign in Israel: an observational study using national surveillance data. *Lancet* 2021; 397(10287):1819-1829.
31. Dagan N, Barda N, Kepten E, *et al.* BNT162b2 mRNA Covid-19 vaccine in a nationwide mass vaccination setting. *N Engl J Med* 2021; 384(15):1412-1423.

32. Wan EYF, Chui CSL, Lai FTT, *et al.* Bell's palsy following vaccination with mRNA (BNT162b2) and inactivated (CoronaVac) SARS-CoV-2 vaccines: a case series and nested case-control study. *Lancet Infect Dis* 2021.
33. Voysey M, Clemens SAC, Madhi SA, *et al.* Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. *Lancet* 2021; 397(10269):99-111.
34. Wu Z, Hu Y, Xu M, *et al.* Safety, tolerability, and immunogenicity of an inactivated SARS-CoV-2 vaccine (CoronaVac) in healthy adults aged 60 years and older: a randomised, double-blind, placebo-controlled, phase 1/2 clinical trial. *Lancet Infect Dis* 2021; 21(6):803-812.
35. Xia S, Zhang Y, Wang Y, *et al.* Safety and immunogenicity of an inactivated SARS-CoV-2 vaccine, BBIBP-CorV: a randomised, double-blind, placebo-controlled, phase 1/2 trial. *Lancet Infect Dis* 2021; 21(1):39-51.
36. Harapan H, Wagner AL, Yufika A, *et al.* Acceptance of a COVID-19 vaccine in Southeast Asia: a cross-sectional study in Indonesia. *Front Public Health* 2020; 8:381.
37. Reiter PL, Pennell ML, Katz ML. Acceptability of a COVID-19 vaccine among adults in the United States: How many people would get vaccinated? *Vaccine* 2020; 38(42):6500-6507.
38. Garcia LY, Cerda AA. Contingent assessment of the COVID-19 vaccine. *Vaccine* 2020; 38(34):5424-5429.
39. Yuan P, Ai P, Liu Y, *et al.* Safety, tolerability, and immunogenicity of COVID-19 vaccines: A systematic review and meta-analysis. *medRxiv* 2020; 2020.11.03.20224998.
40. Salali GD, Uysal MS. COVID-19 vaccine hesitancy is associated with beliefs on the origin of the novel coronavirus in the UK and Turkey. *Psychol Med* 2020;1-3. doi: 10.1017/S0033291720004067 (In press)
41. Barelo S, Nania T, Dellafiore F, *et al.* 'Vaccine hesitancy' among university students in Italy during the COVID-19 pandemic. *Eur J Epidemiol* 2020; 35(8):781-783.
42. Palamenghi L, Barelo S, Boccia S, *et al.* Mistrust in biomedical research and vaccine hesitancy: the forefront challenge in the battle against COVID-19 in Italy. *Eur J Epidemiol* 2020; 35(8):785-788.
43. Lazarus JV, Ratzan SC, Palayew A, *et al.* A global survey of potential acceptance of a COVID-19 vaccine. *Nat Med* 2021; 27(2):225-228.
44. WHO. Ten threats to global health in 2019. Available from: <https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019> (Accessed: 1 July, 2021).
45. Razai MS, Chaudhry UAR, Doerholt K, *et al.* Covid-19 vaccination hesitancy. *BMJ* 2021; 373:n1138.
46. Nichter M. Vaccinations in the Third World: a consideration of community demand. *Soc Sci Med* 1995; 41(5):617-632.
47. Sallam M, Dababseh D, Eid H, *et al.* Low covid-19 vaccine acceptance is correlated with conspiracy beliefs among university students in Jordan. *Int J Environ Res Public Health* 2021; 18(5):2407.
48. Sallam M, Dababseh D, Eid H, *et al.* High rates of COVID-19 vaccine hesitancy and its association with conspiracy beliefs: A study in Jordan and Kuwait among other Arab countries. *Vaccines* 2021; 9(1):42.
49. Al-Sanafi M, Sallam M. Psychological determinants of covid-19 vaccine acceptance among healthcare workers in kuwait: A cross-sectional study using the 5c and vaccine conspiracy beliefs scales. *Vaccines* 2021; 9(7):701.
50. Robertson E, Reeve KS, Niedzwiedz CL, *et al.* Predictors of COVID-19 vaccine hesitancy in the UK household longitudinal study. *Brain Behav Immun* 2021; 94:41-50.
51. Ullah I, Khan KS, Tahir MJ, *et al.* Myths and conspiracy theories on vaccines and COVID-19: Potential effect on global vaccine refusals. *Vacunas* 2021; 22(2):93-97.
52. Bell S, Clarke R, Mounier-Jack S, *et al.* Parents' and guardians' views on the acceptability of a future COVID-19 vaccine: A multi-methods study in England. *Vaccine* 2020; 38(49):7789-7798.
53. Kalam MA, Davis TP, Jr., Shano S, *et al.* Exploring the behavioral determinants of COVID-19 vaccine acceptance among an urban population in Bangladesh: Implications for behavior change interventions. *PLOS ONE* 2021; 16(8):e0256496.
54. Malik A, Malik J, Ishaq U. Acceptance of COVID-19 vaccine in Pakistan among health care workers. *PLOS ONE* 2021; 16(9):e0257237.
55. Abdullah AB. Halal vaccine and the ethical dimension of vaccination programmes. *ICR Journal* 2014; 5(3):450-453.
56. Sallam M, Dababseh D, Yaseen A, *et al.* COVID-19 misinformation: Mere harmless delusions or much more? A knowledge and attitude cross-sectional study among the general public residing in Jordan. *PloS ONE* 2020; 15(12):e0243264.
57. Wang J, Jing R, Lai X, *et al.* Acceptance of COVID-19 vaccination during the COVID-19 pandemic in China. *Vaccines (Basel)* 2020; 8(3):482

58. Al-Mohaithef M, Padhi BK. Determinants of COVID-19 Vaccine acceptance in Saudi Arabia: a web-based national survey. *J Multidiscip Healthc* 2020; 13:1657-1663.
59. Neumann-Böhme S, Varghese NE, Sabat I, *et al.* Once we have it, will we use it? A European survey on willingness to be vaccinated against COVID-19. *Eur J Health Econ* 2020;21(7):977-982.
60. Dror AA, Eisenbach N, Taiber S, *et al.* Vaccine hesitancy: the next challenge in the fight against COVID-19. *Eur J Epidemiol* 2020; 35(8):775-779.
61. Detoc M, Bruel S, Frappe P, *et al.* Intention to participate in a COVID-19 vaccine clinical trial and to get vaccinated against COVID-19 in France during the pandemic. *Vaccine* 2020; 38(45):7002-7006.
62. Sarasty O, Carpio CE, Hudson D, *et al.* The demand for a COVID-19 vaccine in Ecuador. *Vaccine* 2020; 38(51):8090-8098.
63. Echoru I, Ajambo PD, Keirania E, *et al.* Sociodemographic factors associated with acceptance of COVID-19 vaccine and clinical trials in Uganda: a cross-sectional study in western Uganda. *BMC Public Health* 2021; 21(1):1106.
64. El-Elimat T, AbuAlSamen MM, Almomani BA, *et al.* Acceptance and attitudes toward COVID-19 vaccines: A cross-sectional study from Jordan. *PLoS One* 2021; 16(4):e0250555.
65. Elhadi M, Alsoufi A, Alhadi A, *et al.* Knowledge, attitude, and acceptance of healthcare workers and the public regarding the COVID-19 vaccine: a cross-sectional study. *BMC Public Health* 2021; 21(1):955.
66. Malesza M, Wittmann E. Acceptance and intake of COVID-19 vaccines among older Germans. *J Clin Med* 2021; 10(7):1388.
67. Al-Qerem WA, Jarab AS. COVID-19 Vaccination acceptance and its associated factors among a middle eastern population. *Frontin Public Health* 2021; 9(34):632914
68. Skjefte M, Ngirbabul M, Akeju O, *et al.* COVID-19 vaccine acceptance among pregnant women and mothers of young children: results of a survey in 16 countries. *European journal of epidemiology* 2021; 36(2):197-211.
69. Wagner AL, Rajamoorthy Y, Taib NM. Impact of economic disruptions and disease experiences on COVID-19 vaccination uptake in Asia: A study in Malaysia. *Narra J* 2021; 1(2):e42.
70. Rosiello D, Anwar S, Yufika A, *et al.* Acceptance of COVID-19 vaccination at different hypothetical efficacy and safety levels in ten countries in Asia, Africa, and South America. *Narra J* 2021; 1(3):e55.