

COVID-19 Vaccines Hesitancy as a Public Health Concern: Reasons, Implications and Recommendations with Nigeria in Focus

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ABSTRACT

The discovery of the SARS-CoV-2 virus from Wuhan China and its subsequent global spread changed the world scene, with policies on movement restrictions, disruption in the supply chain of commodities, businesses being shut down, or suffering severe losses. As of February 23, 2022, worldwide, there had been more than 420 million confirmed cases of COVID-19 and almost 6 million deaths reported. Vaccination has been an effective means to contain the spread of infectious diseases for decades, especially when therapeutic management is yet to be found. Sadly, there was widely reported resistance to COVID-19 vaccine and this rather became a global threat to its successful use in the global pandemic. This work reviews how extensive the problem has been with reasons and recommendations, using global data and available literature. Data searches online for literature on the extent of the problem of vaccine hesitancy were carried out in Google search, PubMed and Scopus databases as well as on national health and World Health Organization databases. Search terms included 'vaccine hesitancy', 'vaccine resistance', 'vaccine statistics' and 'overcoming vaccine hesitancy'. Published works were then evaluated and selected for use based on timeliness and relevance to the main theme. Although vaccine resistance is historical and widespread globally, identified causes could be localized and include education, seeming marginalization, lack of confidence in authorities, etc. Application of recommendations such as proper awareness and a multi-lingual approach to the dissemination of information can help stem the tide of resistance, improve overall acceptability and overcome the implications associated with this public health threat.

KEYWORDS

COVID-19 vaccine, vaccine hesitancy, herd immunity, public health, vaccine development, global pandemic

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INTRODUCTION

The discovery and rapid global-scale production of vaccines to contain the spread of the COVID-19 virus were perceived as giant strides on the path to success against the global pandemic. However, not many foresaw that this laudable success was to be met by another rapidly generated hurdle: The phenomenon of vaccine/vaccination hesitancy. Although not a new concept, the general awareness of vaccine hesitancy and its somewhat resurgence significantly increased during the COVID-19 spread and the global attention



that has been drawn to the disease and its outcome. Hesitancy to COVID-19 vaccine has been linked to the challenge of controlling of spread and eradication of the pandemic as it has been with vaccine-preventable disease outbreaks prior to this time¹.

Vaccine hesitancy or vaccination hesitancy, put simply, is the opposite of vaccine acceptance. It is the reluctance or disinterest of an individual or a group of persons to voluntarily go for vaccine shots (or services) even when the vaccines are available. It has been expanded to mean a delay and unwillingness in vaccine acceptance by an individual or group of persons (including preventing their families) or the outright refusal of vaccines despite the availability of vaccine services². This reaction to available vaccines could vary depending on the region, religious inclination, time, or vaccine type. Betsch *et al.*³ and MacDonald *et al.*⁴ developed a tool to measure vaccine hesitancy using the 5 C model of person-level determinants looked out for; confidence, complacency, convenience (or constraints), risk calculation and collective responsibility although some researchers have seen such model as being too simplistic to comprehensively cover a seemingly complex public health issue as vaccine hesitancy^{3,4}. In this review, attempts to provide insights into the possible reasons for COVID-19 vaccine hesitancy will be made, giving historical backgrounds, comparing the trends around the globe with particular reference to prevalence in Nigeria (Africa) as well as highlighting the implications of the trend to contain the COVID-19 spread and public health generally. It will conclude with practical recommendations to promote COVID-19 vaccine acceptance and circumvent the widely reported hesitancy.

Historical background: Pandemics are not, in themselves, totally new. Human history would be incomplete without the mention of interceptions with pandemics. Some previously experienced pandemics as reported are presented in Table 1. These pandemics were associated with an exponential increase in human disability and deaths, economic disruptions, interruptions in normal daily routines, political tensions and social anxiety⁵. These characteristic descriptions were no different from the COVID-19 pandemic with its particular devastating economic impact on developing economies, particularly in Africa and the stress test it had on her healthcare system⁶.

Since the time the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was detected in Wuhan, the capital of Hubei Province in China, it has been more than four years. Unlike the incidence of non-communicable diseases, within a short duration after the discovery, almost all regions of the World reported cases of the disease, emphasizing the high rate of transmission⁸. Several preventive measures from the government were rolled out, ranging from non-pharmacological policy responses, a ban on large gatherings, travel restrictions, suspension of activities (e.g., academic programs) via the traditional in-person learning methods in schools, stay-at-home orders and similar ones. Emphasis was laid on preventive individual efforts to wear face masks, personal hygiene, physical and social distancing and limiting interpersonal contact, especially for persons not of the same household. While these means helped to reduce the transmission rate of the virus, vaccination has been reported as the effective means to ending the spread of this ravaging menace as scientific research to develop approved medicines to manage the infections is ongoing⁹.

Hesitation to COVID-19 vaccines and vaccinations are getting the most attention at this time, but there are and have been other vaccines, successfully developed by humans and effectively offered protection against deadly diseases such as diphtheria, tetanus, poliomyelitis, pertussis and measles¹⁰. Sadly, as with the COVID-19 immunization products, many children populations around the world are not sufficiently covered by vaccines, especially true in West Africa, where immunization rates in children (although now improving) are still low when compared to other parts of the world. Public vaccination is reported to have started in 1796 in the United Kingdom when an 8 year old boy was injected with cowpox virus obtained from fresh lesions from a patient to prevent others who were not infected from coming down with

Table 1: Some known pandemics in human history

| Pandemics in human history | Timelines |
|------------------------------|-----------------------------|
| Black death | 1334 |
| Justinian plaque | 1600s |
| Spanish flu | 20th century(1918-1920) |
| Human immunodeficiency virus | 20th century (1980s) |
| COVID-19 | 21st century (2019-to date) |

Source: Huremovi⁷

Table 2: Developments relating to vaccine hesitancy in recent human history

| Timelines | Developments contributing to vaccine hesitancy |
|--------------|--|
| 18th century | English physician, Jenner, learned cowpox scrapes can protect people from smallpox and gave the scientific foundation for a vaccination with the use of cowpox (variolation) as a vaccine against smallpox Vaccine opposers reasoned that vaccination is the introduction of something unnatural into the body and this would interfere with one's relationship with God |
| 19th century | Laws on vaccination came up. The United Kingdom Vaccination Act requiring parents to get their infants vaccinated by 3 months old or face fines or imprisonment, was set up in 1853. Organizations opposing vaccination e.g., the anti-vaccination League of London formed in 1867 opposed the law for reason that it runs contrary to personal freedom. In Massachusetts, United States, mandatory laws on vaccination were passed whereas activists against vaccination made attempts at opposing as well as appealing such laws Several other anti-vaccination voices via publications sprung up in the late 1800s affecting the vaccination coverage in Europe |
| 20th century | Between the 1920s-1970s more vaccines (e.g., Measles, Polio, Diphtheria and Pertussis), were developed and children in public schools were to receive most vaccines in the United States. The catastrophe linked to the Cutter laboratories' polio vaccine incident of the 1950s fueled distrust in the pharmaceutical industry and reduced the interest in vaccine use In 1982, the Media and some health professionals via documentaries raised alarm about the adverse effects of some vaccines and these significantly affected the public view on vaccine safety. Litigations and counter-litigations against vaccine manufacturers soon became rampant and an anti-vaccine group was formed in the United States. A study in the United Kingdom by Andrew Wakefield, linked vaccines (particularly mumps, measles and rubella) to autism and this significantly dropped the level of vaccine acceptance in the UK in 1998, although this finding is yet to be verified |
| 21st century | The popularity of social media and its use by public figures (influencers) to circulate slick documentaries on vaccination and vaccines have repackaged and promoted vaccine misinformation and myths promoting heightened negative responses to vaccine use The law in California, United States that prohibited optional vaccination because of religious beliefs, also sparked a resurgence in the anti-vaccine advocacy |

Source: Omer *et al.*¹, Riedel¹¹ and Nuwarda *et al.*¹⁴

smallpox by the 1800s this procedure (vaccination) had rapidly spread to Europe¹¹. This move was a direct offshoot of the discovery that variolation procedure - the introduction of dried scrapes of lesions from a patient with pox virus by inhalation or inoculation method could serve as a vaccine to protect against the infection with smallpox. Interestingly, it must be stated, however, that variolation itself in its different forms had been reported in practice in parts of Asia (China) and Africa (Egypt) as far back as 1000 AD¹². Despite the progress in vaccine discovery and production in human history, its resistance, although first seen in the 1790s, was first documented in 1809 with the introduction of the term anti-vax as a public health lexicon¹³. Table 2 presents some of the key highlights in vaccine development and resistance in the timelines in human history.

COVID-19 VACCINES

A worldwide effort was put into research and collaboration among scientists and bio-pharmaceutical manufacturers to develop efficient vaccines in a short time to combat the SARS-CoV-2 virus early on in 2020. Governments and multinationals put in financial support to fund such research works. Big publishing houses opened up their repertoire of libraries for information availability and knowledge sharing. Thankfully, within months, there was a direction as to where help in combating the aggressive viral spread, likely, will come: The vaccines!. According to available data, as of January 22, 2022, about 60.3% of the

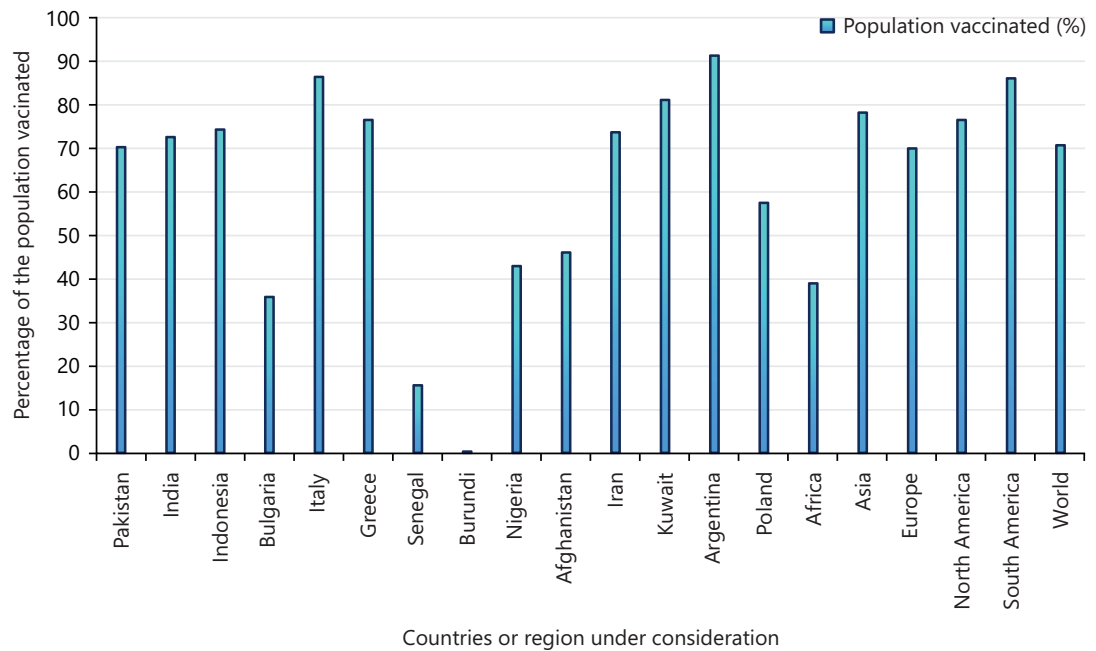


Fig. 1: COVID-19 vaccine coverage around selected countries of the World as of December 4, 2023

Source: Rupani *et al.*¹⁶

world population had received at least one dose of the COVID-19 vaccine, as millions of doses were administered every day although the least coverage in vaccination was in Africa as revealed in the data from our world in data¹⁵. Consequently, less than 10% of the population in low-income countries received the same dose of the vaccine at the same time. More than a year later (specifically December 4, 2023), the global percentage of persons vaccinated had increased to over 70% and countries such as China, Qatar, Singapore and Chile recorded over 90% vaccination in their population, several others in Africa were still far behind¹⁶. Figure 1 presents sample data on the percentage of population vaccinations in selected countries and regions around the world.

Still, more vaccines of different varieties have been produced by different pharmaceutical manufacturers with approvals from regulatory authorities. Despite this rapid progress reported in the development and rollout of vaccines, the delay/reluctance in accepting or outright rejection of these available vaccines is worrisome. This has been the reality with COVID-19 vaccinations-vaccine hesitancy - which, according to the World Health Organization SAGE group, must be properly understood and well diagnosed to identify the drivers and appropriate strategies designed to address it in line with specific determinants and settings¹⁷. The problem of vaccine hesitancy serves as a cause for concern as it relates to vaccine coverage and public health.

Persons who resist vaccines have been classified by Bunch (2021) into 3 groups: The "anti-vaxxers", describing persons who oppose all forms of vaccines and vaccination, not just the COVID-19 vaccine; those who refuse some vaccines but accept others and the third group who accept vaccines but have some problems about doing so¹⁸.

In a survey by Arce *et al.*¹⁹ between June 2020 and January 2021, across 15 studies carried out in Africa, South Asia, Latin America, Russia and the United States, findings from Russia and the US were compared with those from an upper-middle-income country (Colombia), five studies in lower-middle-income countries LMIC (e.g., India, Nepal, Nigeria and Pakistan) and seven studies in low-income countries (Burkina Faso, Mozambique, Rwanda, Sierra Leone and Uganda)¹⁹. It was noted that the vaccine

acceptance rate from the LMICs was higher than that of samples from the United States and Russia. The average acceptance rate was 80.3%, the lowest being in Burkina Faso (66.5%) and Pakistan (66.5%). Some reasons for their hesitancy were lack of information, concerns about side effects and the vaccine efficacy.

As indicated earlier, vaccine hesitancy has been a challenge long before the appearance of the COVID-19 pandemic on the world stage as vaccines for preventable diseases like measles, polio, diphtheria, etc., experienced some hesitancy with resultant decreased immunization coverage. Since the COVID-19 vaccine suffers from this same phenomenon, it becomes imperative to understand the causes and implications of hesitancy to vaccines to address this global threat to health.

COVID-19 VACCINE HESITANCY: REASONS

The reluctance, delay or outright refusal to get vaccinated may be seen as a decision-making process carried out, by an individual or group, despite vaccine availability. However, Soares and coworkers (2021) see it differently²⁰. They see vaccine hesitancy to be beyond the decision-making process, influenced by individual and group context, or vaccine-specific factors. Such factors as communication and media, historical influences, religion/culture/gender/ socioeconomic, politics, geographic barriers, experience with vaccination, risk perception and design of the vaccination program²⁰. Therefore, understanding the reasons behind COVID-19 vaccine hesitancy is a vital step in tackling it.

Controversies surrounding COVID-19: The coronavirus has arguably had a high number of controversies associated with it since its discovery. Controversies such as the disease outbreak, its spread, timely reporting of cases, proposed management and workable therapies, The controversies which are put forward by different strata of society, particularly intellectual minds and researchers started with the seemingly proposed delay in the reporting of the outbreak to the World Health Organisation (WHO) when first observed in the nation of the first detection. It was further compounded when researchers expressed concerns after scrutiny of the data underlying the conclusion drawn from the article (now retracted) on the use of existing medicine such as chloroquine and hydroxychloroquine for the treatment of COVID-19 that was published in the Lancet Journal. Such request for scrutiny led to the retraction of the article and a similar one which reported on the combination of chloroquine and macrolide in COVID treatment, published in the New England Journal of Medicine²¹. This latter work was criticized and the data source questioned by international highly placed scientists and statisticians. Others have had to question the approvals of the regulatory agencies during this period. Figure 2 shows some of the effects of controversies surrounding the COVID-19 vaccines.

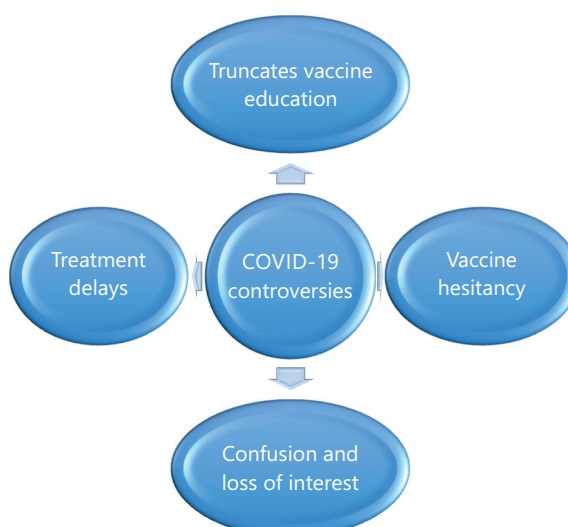


Fig. 2: Resultant effect of controversies associated with the COVID-19

Level of education: Educational status has been found to play a role in hesitancy toward the COVID-19 vaccine. Individuals who have had a university education were more likely to take the vaccine than those who have a lower level of education²⁰. In the study by Fisher *et al.*²², it was discovered that having a lower educational status was one of the strongest predictors of being reluctant to the COVID-19 vaccine. A person's educational status could give him the exposure to appreciate the importance of vaccines, the capacity to understand the guidelines associated with their administration and side effects and likely result in his readiness to get vaccinated. It must also be pointed out, however, that education could also be a bottleneck in the drive for total vaccine coverage. Education level could contribute to a reduced level of adherence to vaccine policy, in which case, those highly educated could start questioning the whole vaccination process, advocating contrary opinions as well as protesting their fundamental rights in attempts at having a say.

Lack of confidence in the vaccines, health systems and policymakers: Confidence in COVID-19 vaccines refers to the trust and belief that the vaccines are safe and efficacious²³. A lack of trust and confidence in the health system and the vaccines made available by such systems and policymakers are common reasons COVID-19 vaccine hesitancy²². How vital then that key players in the health sector maintain excellent professional practice over time to sustain public trust even on vaccine recommendations²⁴. Some individuals have lost confidence in the moves of the government in encouraging vaccinations blaming such authorities for allowing nuances of politics in healthcare, particularly with vaccination programs especially where there had been a historical precedent of unpleasant experiences or outcomes. On the other hand, others have a low perception of the pharmaceutical companies producing the vaccines reasoning that these are simply all out for profit making^{1,23,25}.

True, the time interval between the development and approval process for the COVID-19 vaccines was comparatively shorter than other vaccines, many have interpreted such rapidity as coming with the possible compromise of some standard precautions or protocols especially during the approval stages, thus questioning the quality of vaccines produced²⁶. In a study by two researchers, Aldakhil *et al.*²⁷ some of the common concerns about the vaccines as expressed by some of the participants surveyed included concerns as to insufficient time for long-term appraisal of the health implications of the vaccines as to any, allergenic components and symptoms. vaccines not being subjected to enough clinical trials and limited knowledge of the long-term side effects of vaccines. Others expressed concerns as to the side effects observed in their close relatives who had been vaccinated. In another study by Wang *et al.*²⁸ researchers focused on the problem of vaccine hesitancy among adolescents in Africa, almost half of those surveyed agreed that they would delay taking COVID-19 vaccination until the safety and efficacy of the vaccines were well established. Beyond the common side effects of the COVID-19 vaccine, as it is with other products for immunizations, such as pain, redness and swelling at the point the shot was administered fever and muscle pain, there have also been concerns about the risk of blood clots and rare side effects reported with the AstraZeneca vaccine²⁹. These findings no doubt emphasize that questions on vaccine safety and its side effects are important subject matter of public health concerns that if not well addressed could contribute to serious trust issues entertained by some persons hesitant about the COVID-19 vaccine^{30,31}. Many have had to question why the COVID-19 vaccines were developed so rapidly when the same fast pace could not be replicated for vaccines for HIV that are yet to hit the markets after several years of research.

Before the COVID-19 vaccine, vaccine development has been known to take time, spanning years. Hence, the expressed concern by the general public about the rate of the COVID-19 vaccine development and relative ease of procurement from advanced economies is not a misplaced concern for it was a phenomenon that was yet to be achieved³².

Challenge of complacency and convenience: Where there is a low or non-existent perceived risk of contracting COVID-19, complacency readily sets in because individuals will consider vaccination, which is intended as a means to prevent the viral spread, as unnecessary³³. Such reasoning by some that they

are less likely to be infected with the virus may be due to the relatively low infection-fatality rate or that some individuals may have had no personal experience of a loved one or someone they know to have fallen critically ill or tragically passing away as a result of COVID-19 infection³³.

That complacency leads to vaccine hesitancy may also be possible because of vaccines-success-irony. This is well exemplified by the fact that past vaccine-preventable diseases may have been erased of their lasting harm by the administration of vaccines scores of years ago so those unpleasant effects have become less obvious in society today due to successful vaccination campaigns. Thus, many today who oppose or hesitate to take vaccines (COVID-19 vaccines in this case) may have just a limited knowledge of the woes that those diseases (now prevented and decimated by vaccination) wrecked on the world and the benefits provided by vaccination become somewhat difficult to discern, resulting in complacency³⁴. Worth mentioning too is that the COVID-19 disease is seen by some to have been overly exaggerated and blown out of proportion by the mainstream media, social media and political actors of the government³⁵.

The availability, affordability, accessibility and comfortable delivery of vaccines describe convenience²³. The ease of access to vaccination including the location of the COVID-19 vaccine, delivery and time may contribute to hesitancy³⁶. The disruption of the supply chain and refrigeration requirements for vaccines are some obstacles to accessibility¹⁸. A vaccine rollout is not considered successful if it is inaccessible to those who need it and procurement is inconvenient. Such inconveniences may predispose potential beneficiaries of the vaccines to become reluctant to take them or outrightly reject going through the stress.

Myths, misinformation and belief in conspiracy theories: There is a myriad of information about the coronavirus and the COVID-19 vaccines, readily accessible on the internet and social media platforms. While few may be factual, many are less than true and intended to mislead. The difficulty in distinguishing one from the other is what has likely led to thriving misinformation about vaccines. That fake news was spreading in the media faster than the virus itself led the WHO (World Health Organization) to term the situation an infodemic with a hugely disastrous impact, as reported by a study in the first 3 months of the pandemic in 2020, where about 6000 persons were hospitalized and some 800 died after acting on rumors and misinformation that were peddled as to the cure of the coronavirus³⁷. Such misinformation along with disinformation presented as rumours (e.g., vaccine is unsafe) has been robust on the social media and identified as the biggest challenge to success of the vaccination program around the world and in Jordan³⁸.

In Africa, some persons hold the opinion that conceding to vaccination is agreeing to be subjects of experimentation for Western vaccines²⁵. That government and influential elites, (such as Bill Gates), are using the vaccines (which they claim contain microchips) to track people's behaviours as well as influencing the course and outcome of the pandemic were some of the many widely circulated conspiracy theories about COVID-19^{38,39}. Findings from a survey carried out in a Nigerian university included beliefs that were responsible for reluctance to get vaccinated; COVID-19 can be easily resolved by taking chloroquine; the belief that the body's immunity is strong enough against the virus; the vaccine is not needed if one is not infected with the virus especially because of being of the black race³¹. The impact of the spread of myths and misinformation associated with COVID-19 on vaccine hesitancy is illustrated in Fig. 3.

Religious beliefs have been associated with hesitancy toward the COVID-19 vaccine although the degree of their effect has been region-dependent from available studies^{28,31,35}. Furthermore, many current conspiracy theories and complacency are linked to religious beliefs, just as the failure to eradicate polio today in Pakistan is attributed to such theories⁴⁰. In a survey of 193 front-line skilled nursing facility staff regarding COVID-19 vaccine hesitancy, some of the dominant convictions of the respondents were that

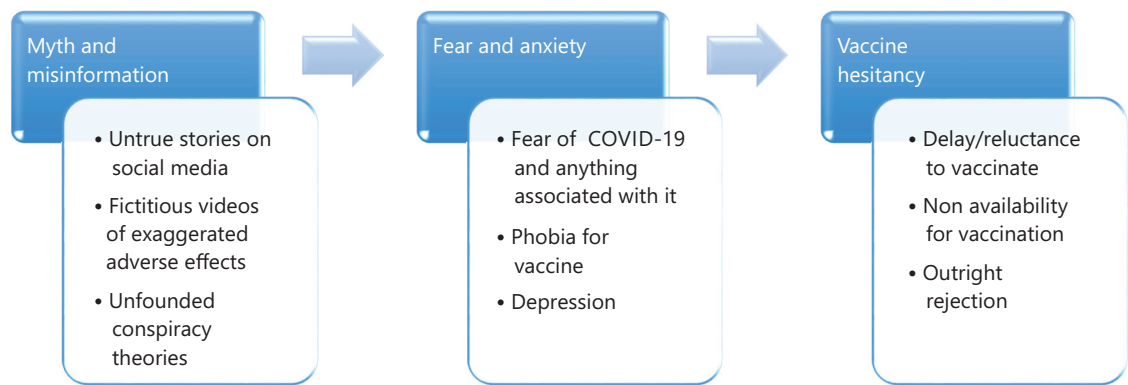


Fig. 3: Outcome of the misinformation and myths on reluctance to vaccination

faith in God has been protecting them, implying that they do not need a vaccine; others object to the source of the vaccines and its constituents (e.g., suggested fetal cells from abortion) as being against their conviction; while some staff members linked the vaccine with the mark of the wild beast referenced in the last book of the bible⁴¹.

Ethnicity and minority groups: One's ethnic group has been associated with being more prone to rejecting vaccination services. This is especially so for minority groups, for instance, who have experienced marginalization over the years or current discrimination for political, demographic, or other reasons. These may consider the sudden turning of attention to them for access to healthcare and vaccination services with suspicion^{24,42}. A minority group of migrants and asylum seekers may view registration for vaccination as a ploy by the government to track and deport them.

The language barrier could contribute to the challenge of vaccination of the minority group resulting in communication gaps whereby all information about the vaccination in the mainstream media is done in a language not well understood by the group. Kadambari and Vanderslott⁴³ have reported a low percentage of vaccination of the Blacks and Black British as compared to white British and the Irish. Other studies have shown a high level of hesitancy toward the COVID-19 vaccine among the black population^{24,42}.

Hesitancy in health workers: Health workers as well as students-in-training in the health profession can influence some patients who look out for and emulate them in health matters. There is abundant evidence that some patients will not attempt a medical decision without a clinical recommendation from an expert³⁹. Thus hesitancy found in health workers themselves can fuel hesitancy in other persons and negatively affect the success of any strategy in place for vaccination^{38,39,42}. Hesitant health workers tend to transfer their perceptions almost effortlessly to patients when they provide care or counsel²⁴. This could be in their reaction to patients' questions about their opinions or reservations they may have on the COVID-19 vaccines. With the full conviction that these know better as they demonstrate in other diseases (even in non-communicable ones) and that their decision should be sound, many patients may tend to follow such a course of vaccine hesitancy as demonstrated by some health workers^{28,44}.

IMPLICATIONS OF VACCINE HESITANCY

Compromise on the protection offered through herd immunity: Public vaccination makes possible herd immunity, that is collective immunity within a given population. Such immunity serves as a protection for the vulnerable group of society who are not considered safe to take vaccines. Herd immunity is achieved when a sufficiently large number of persons who have been vaccinated in a population gain immunity thereby conferring, indirectly, protection from infection on the susceptible individuals (unvaccinated persons) in that population. The more the number of persons vaccinated in a community,

the lesser the disease spread and by extension the better protected from infection such susceptible individuals of that community will be who may not and cannot be vaccinated against the disease; the immunocompromised patients and the very young⁴⁵.

Estimates on COVID-19 point out that to contain the forward transmission of the virus and community spread of the virus, about 60-75% immune individuals would be necessary²³. On the other hand Anderson *et al.*⁴⁶, estimate that a vaccine of about 80% efficacy, will require between 75-90% of the population vaccinated to achieve herd immunity given that the reproduction number of the infection within that population and the life-span of the immunity are known. Thus to attain herd immunity against the COVID-19 disease in the global on-going rollout of vaccinations, the increasing vaccine-hesitant group may be a key determining factor. Interestingly, the strong influence of antivaccine population (who may not be many) may even sweep off a rather larger population of the undecided making herd immunity difficult to achieve³⁹. Hence not achieving herd immunity is a significant threat to public health worldwide⁴⁶.

Increase in disease spread, viral burden and development of new variants of SARS-CoV-2: The emergence of new variants of the COVID-19 virus has been reported in different parts of the globe. Just like other RNA viruses, the COVID-19 virus readily undergoes genetic evolution to adapt to the human host and with time develops mutants. As of the writing of this paper, five variants of concern (those having high transmission rate and virulence) have been identified; the alpha (B.1.1.7), beta (B.1.351), gamma(P.1), delta(B.1.617.2) and currently the omicron (B.1.1.529) variants⁴⁷. There is a slow emergence of new variants or truncating of the mutation process when COVID-19 vaccination is followed³². Beyond preventing new infections, vaccines can reduce the severity of the illness, multiple hospital admissions and death resulting from COVID-19. When the percentage of a population required for herd immunity is not attained, the virus gets sufficient opportunity to keep mutating freely, producing new variants²⁹. Such is the implication of hesitating to take the COVID-19 vaccine. While different countries are making efforts to reach regional collective immunity, at present the omicron variant, a variant that spreads faster across the regions even though fatality rate has not been as high as previous strains.

Economic loss resulting from investment in vaccine development: Vaccines are not farm produce obtained from cultivated fields nor are they products of atmospheric precipitation! Even those (farm produce and atmospheric precipitation) which seem to be free of charge have a measure of financial implications. So much is invested in finances and robust intellectual exercise to invent, develop and manufacture vaccines in commercial quantities and subsequently activate the supply chain for logistics and distribution. While the actual production cost is not readily made available from manufacturing companies, published works estimate the net cost of manufacturing 100 million doses (just at the stage of readiness for shipping) at US\$ 0.54 to US\$ 0.98 a dose. On average, the estimated selling price of a single vaccine line, depending on the vaccine product and the region despite non-profit claims by manufacturing companies, goes from as low as US\$2.15 to as high as \$23.50 per dose⁴⁸.

Although for many nations in low and middle-income countries, the vaccines are supplied as donations, funded by industrialized nations, charity organizations, or philanthropic actions of some individuals and international institutions. The bottom line is that some people actually do pay. All such costs that had been put into the different stages from conception to delivery would amount to a loss and wastage when the vaccines being made available and accessible are resisted or rejected by patients. In Nigeria for instance consider the cost of about a million doses of the AstraZeneca vaccine that was destroyed due to their expiration⁴⁹. True, as reported, some of these vaccines were short-dated even when supplied, but resistance to accepting them may have contributed to the delay in their use and the huge sum and cost implication.

Vaccine hesitancy could prolong the pandemic and associated governmental restrictions: When the graphical curves of the COVID-19 incidence keep indicating rising spikes, the duration of the pandemic is invariably extended and enforcing preventive laws on social distancing and lock-downs for a longer time is justified. Such delays prolong the interruption of normalcy to businesses (with resultant financial losses), truncate academic calendars (with delay in school completion) and interfere with food supplies and healthcare supplies.

RECOMMENDATIONS TO OVERCOMING COVID-19 VACCINATION HESITANCY

The dire consequences of hesitancy to the COVID-19 vaccine underscore the need to provide solutions to tackle it. To achieve this, collaborative effort is needed from all involved in the vaccine channel; government and policymakers, researchers and vaccine developers alike, healthcare workers and public health advocates, the media and others to accurately inform the public to sustain public confidence in COVID-19 vaccines²⁴. Some critical areas to work on to circumvent the vaccine hesitancy threat and win the pandemic war are as highlighted below.

Replacing misinformation with accurate and timely information: The effects of misinformation can be so deep that it could sustain hesitancy for an extended period and affect a large population. Misinformation could be adequately tackled when public health authorities and the government provide the public access to necessary, timely and accurate information on COVID-19 and its vaccines. Such information in a timely fashion removes any gap that may fuel suspicion and misinformation. Thus, the public's eyes are opened to see beyond the negative emotional appeals and fake news employed by unscrupulous anti-vaccine campaigns, so that their real motives become obvious to the discerning public³⁰. Also, when policymakers engage with communities to combat misinformation and unfounded rumours about the vaccine, a positive outcome could result⁵⁰. Such engagements help in addressing the public's concerns. To be effective, beyond giving accurate information about the vaccine, in order to dispel rumours, understanding the deep-seated reasons (which could also be longstanding) for the stance of the population opposing COVID-19 vaccines is vital as this can shape how best to communicate the accurate and timely information³⁹.

On the concern of many about the speed of development of the COVID-19 vaccines unlike other vaccines, this could be addressed through good communication and enlightenment. The enhanced speed of development of the COVID-19 vaccine could be due to several factors such as rapid SARs-CoV-2 virus genome sequencing; the inherent efficiency of mRNA and novel vaccine development technologies adopted for use; running consecutive trials simultaneously to save time; or the global concerted effort made amongst researchers^{29,39,51}. It must be added too that another possible factor could have been overwhelming support of researchers (via finance, legislation and collaborations) by the government and organizations around the globe in the face of the global threat led to remarkable outcomes. Such worldwide efforts geared towards a goal and with all needed support likely contributed to the removal of any bottleneck delay and the enhanced speed of vaccine development. More so, for those who raised eyebrows as to the rapid approval of the COVID-19 vaccines for use, giving clarifying information on the emergency use authorization as at then, considering the need to achieve herd immunity at the time, being different from the conventional regulatory approval is vital⁵¹.

When such explanations are made readily available and accessible by public health authorities, the public is then reassured that no routine safety assessments of the vaccine have been compromised for speed³². For the common side effects, the public should be made to understand that they are temporary. The mild pain can be relieved with over-the-counter analgesics such as acetaminophen, ibuprofen etc., if they have to take any medication. The medicines are, however, not recommended to be taken before vaccination in a bid to prevent these side effects⁴⁵.

Gaining public trust and confidence in the vaccine-a necessity: Fear and distrust, fueling agents for COVID-19 vaccine hesitancy, can be reduced by building public trust and by employing techniques of transparency on available information on COVID vaccines and their research. True, not all available result data is to be necessarily revealed as some raw data may not be understood by the public, but letting the public in on the comprehensible results at every step of clinical trials and the protocols is key; making this information accessible to them so that they are brought up to speed to which enables them to understand the decision of policymakers and the scientists²⁴. This and other similar moves by governments and health authorities should enhance efforts to encourage trust in vaccines²⁰. For example, Chief Executive Officers (CEOs) of nine vaccine manufacturing companies pledged during the pandemic to uphold the integrity of the scientific process, thus reducing the fears that clinical trials are being politicized simply to speed up development²⁹.

Although pharmaceutical companies may be perceived to be less transparent when it comes to research findings, they may present even their 'negative' findings as they occurred in research: Any unfavourable results or adverse events, delays, or setbacks in vaccine testing, can boost the public's trust in these companies and their operations^{18,25}.

Building trust would also be vital for editors and reviewers for academic publishing houses to be more vigilant when assessing manuscripts and data presented for publication so that falsified data and suspicious write-ups are nipped before they pass for publication. This will also mean that when any false claim is discovered in published works, any action against such authors and their affiliated institutions be made widely circulated, serving as a deterrent to others and dousing suspicion in the discerning public. The health system must also be on the lookout for actual, potential, or perceived adverse medical events so that these are appropriately addressed when engaging the public to build trust^{24,52}.

Coercion to vaccination breeds suspicion and triggers hesitancy: Forceful methods of implementing vaccinations have had stiff opposition in history¹. The authoritarian approach raises questions as to the sincerity of purpose, provokes suspicion by minority groups and the public in general and soon erodes confidence in the vaccination process. Some may reason if the vaccination is so good why does it have to be forced? Can the benefits rather not be demonstrated than pushed on them forcefully? Historical attempts at curbing vaccine hesitancy with coercion have often failed, they have had very little impact on actual vaccine intake but rather fueled vaccine hesitancy³⁹. It is important to note that healthcare matters are for personal decisions, hence people have the free will to choose to take vaccines or not. However, they should be made to know the implications of their decision and the consequences on the greater population, even if that will mean they are deprived privileges of gathering in larger crowds to prevent disease spread³². When matters are handled this way, the public will be more likely to trust other moves by authorities.

Creating awareness, sharing knowledge: Increasing awareness and vaccine education are pivotal to achieving better vaccine coverage. Individuals should be educated about vaccines, why they are necessary, herd immunity, vaccine safety and effectiveness, which brands are available and where they can access vaccination services, thus equipping them to make informed decisions. Such awareness should be done in more than the mainstream media or language, to reach seeming minority groups³⁶. Campaigns should be launched on social media to reach the large population of youths who are active users of social media as well as visible physical campaigns from street to street or house to house, if possible, to create awareness in the public about the importance of vaccination for global public health²⁹. During the awareness programs, efforts should also be geared toward making accessible, reliable and consistent information on all the benefits and risks of vaccinations. The public should also be educated on how to screen information sources for authenticity and reliability while not censoring any who hold a different viewpoint³².

In making the public aware, creative communication skills can be invaluable. Storytelling is an innovative and engaging means of conveying information and visual aids (scientific videos which have a lasting impression) may be used. The personal stories, for example, of individuals who have lost a loved one to COVID-19 or had one who was critically ill or these persons themselves, can have a lasting impact on the public. Another employable creative skill in communication is the use of short videos. A study reported that making and sharing short scientific videos about the vaccine on social media is the most effective method to encourage people to take the vaccine^{37,38}.

Involving trusted members of society: Working with persons who are recognized and esteemed by the population; celebrities, trusted social media influencers, persons who have a large following on social media platforms, religious leaders, community group heads, champions, high profile members of the society, to reduce hesitancy could be an effective measure. Aside from active advocacy, such individuals just by getting vaccinated and being involved in the process can turn things around, increasing the acceptance rate³⁶. As an example, the Cutter Laboratory tragedy that struck in the US in 1956, in which out of the 200,000 children vaccinated with the defective Salk vaccine that mistakenly contained active poliovirus, 40,000 contracted polio, resulting in 10 deaths and 200 children with varying degrees of paralysis²⁹. This was indeed a huge setback to the polio vaccination campaign. Weeks later, the error was discovered and new vaccines were produced, devoid of any contributions or involvement of the Cutter Laboratories. One of the effective measures that were employed in resuming polio vaccination again was calling on numerous high-profile individuals to advocate for the vaccine, join the fundraising effort and educate people about polio and the vaccine, were celebrities and professionals who joined the campaign to convince teenagers to get vaccinated²⁹.

Findings from a study by Momplaisir *et al.*⁵³ reveal that a trusted medical provider has a significant influence on vaccine decision making as some respondents expressed that a positive or negative recommendation made by such trusted health providers can influence their decision accordingly. Hence the need to build a trusted relationship between health providers and patients. Healthcare providers can find out the specific concerns of patients about the COVID-19 vaccination, respectfully listen, respond accordingly following full understanding of those concerns and offer practical support to those who are yet to decide about the vaccine²⁹.

Not to be disregarded too is including seemingly comfortable environments such as schools, religious sites, shopping centres and workplaces as vaccination sites can increase vaccination rates as some persons reluctant to go to health facilities can now access vaccination services at these locations.

CONCLUSION

The COVID-19 vaccine hesitancy is indeed weakening the ongoing global effort made in the fight against COVID-19. Vaccines are constantly being produced and rolled out and the setback, hesitancy, possible reasons and implications have been highlighted. Overcoming COVID-19 vaccine hesitancy is not as effortless as the breathing process nor a quick fix as forceful administration. It involves a concerted effort from everyone; public health authorities, policymakers, pharmaceutical companies, high-profile members of society/celebrities, researchers, healthcare workers, researchers, communicators and the media. The COVID-19 vaccine hesitancy is indeed a significant threat to public health, affecting how long the SARs-CoV-2 virus will continue to remain and cause havoc. Overcoming this threat will ensure better vaccine coverage, achieve desired herd immunity, reduce the duration of the worldwide health challenge and eventually help win the fight against the global pandemic.

SIGNIFICANCE STATEMENT

This study identifies the reasons that limited the wide acceptance of the COVID-19 vaccine as the pandemic surged on and the insight is very beneficial for understanding the behavior pattern of the

population and what was responsible. This study will help policymakers and health authorities manage present resistance to immunizations as well as prevent and prepare for any future disease outbreak to achieve a robust public health status.

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