

COVID-19 vaccine hesitancy in Sana'a, Yemen

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Abstract

Background and Aim: The development of a coronavirus disease 2019 (COVID-19) vaccine is ongoing. This study aimed to prepare for public acceptance of the vaccine. There is a need to identify the current acceptance and potential barriers to receiving a COVID-19 vaccine in Yemen. Understanding the hesitancy and acceptance of a COVID-19 vaccine are crucial to develop local evidence-based interventions.

Materials and Methods: Twenty students were interviewed in this study. An interview guide was developed and it addressed the willingness to accept a future COVID-19 vaccine. In-depth interviews were conducted, transcribed, and manually analyzed.

Results: The majority of participants agreed that they would take a COVID-19 vaccine for several reasons, including protection for themselves, their families, and others and to stop the spread of COVID-19, for which the vaccine is important, as in other routine vaccinations. However, some participants shared that they would not take the COVID-19 vaccine due to the following reasons: Concerns regarding the safety of the vaccine; feeling fit and healthy, and thus considering themselves to have strong immunity; feeling that the vaccine was manufactured in a rushed manner and thus it would require approval by the World Health Organization; being previously infected with COVID-19 and considering themselves protected, and placing their trust in God and believing no vaccine was needed.

Conclusion: The willingness to receive a future COVID-19 vaccine was high among medical students. However, some students hesitated to take the vaccine. Therefore, mass media interventions are required to maximize vaccine uptake.

Keywords: coronavirus disease 2019, coronavirus, pandemic, vaccine acceptance, vaccine barriers, vaccine hesitancy, vaccine uptake.

Introduction

Vaccination has long been considered the most reliable method for preventing the spread of infectious diseases [1]. Vaccines are the most cost-effective investment in health [2]. According to the Center for Disease Control and Prevention, vaccination is the most important public health success achievement of the 20th century [3]. The reduction in the occurrence of infectious diseases, such as polio, measles, diphtheria, yellow fever, and pertussis has repeatedly demonstrated its value.

Global vaccine hesitancy is becoming more widespread [4]. Vaccine hesitancy has been linked to outbreaks of pneumococcus, measles, and pertussis [5], all of which are serious and life-threatening diseases that can be prevented through vaccination. Adult influenza vaccine coverage in the United States

decreased by more than 6% in 2019, with only a 37% vaccination rate [6]. These patterns could explain the rise in vaccine-preventable diseases, such as measles in the USA [7] and the 30% global increase in its cases [8]. During the 2019-2020 season, the number of hospitalizations and deaths due to influenza increased significantly [8].

Incredible progress has been achieved since the discovery of the SARS-CoV-2 virus and its genome. Vaccine hesitation remains a major obstacle in vaccine adoption. Vaccine acceptance is critical for maximizing herd immunity, which is required to protect vulnerable communities. However, a coronavirus disease 2019 (COVID-19) vaccine may be unsuitable if a person is immunocompromised and has a pre-existing medical problem. A vaccine refusal incidence of above 10% may seriously hinder herd immunity. Therefore, the preparation of national planning strategies to address this issue is vital.

Vaccine hesitancy is not a modern phenomenon; it started shortly after the smallpox vaccine was introduced at the end of the 18th century [9,10] and has endured ever since. The claims and views of anti-vaccination groups have not changed much over the past two centuries, but their capacity to

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disseminate information has increased over the last decade [11,12].

Vaccine safety is the main concern owing to the accelerated production and testing processes during the pandemic. Anti-vaccine groups and mistrust of the government's response to the pandemic are other challenges to be addressed before and during the COVID-19 vaccination campaign. Several studies have shown many factors that need to be addressed to support vaccine acceptance for the introduction of a new vaccine [1,4,6].

Some of these factors include the vaccine's effectiveness and protection, as well as adverse health effects, misconceptions about the need for vaccination, a lack of faith in the healthcare system, and a lack of knowledge and understanding of the vaccine-preventable diseases [13,14]. As such, hesitation issues with COVID-19 vaccinations should be discussed before and during vaccination programs.

Acceptance for vaccinations is dynamic in nature, context-specific, and differs across time and nations. Understanding Yemen's unique context, culture, habits, beliefs, and traditions are important for providing recommendations for local intervention designs to maximize COVID-19 vaccine uptake by Yemen's general population. Some studies have reported that lack of infection, confidence in the vaccine's safety, and vaccine efficacy have reduced vaccine acceptance [13-16]. In 2009, during the H1N1 pandemic, vaccine hesitancy became apparent. Most countries indicated that the vaccine was received by <50% of the target population, and the majority of the population felt that they had a low risk of H1N1 acquisition [15,16].

In a French study, 26% of a group polled 10 days after the introduction of a national lockdown said they were against vaccination [17]. This was more common among the low-income population and those over 75 years of age who were at high risk for COVID-19. Misinformation that leads to vaccine hesitation may put public health at risk during the current crisis. Before the COVID-19 vaccine becomes available in Yemen, the bases for public acceptance of future COVID-19 vaccines need to be carefully understood. Addressing the known potential barriers to vaccine acceptance through a mass vaccination program using local linguistic and culturally competent messaging is an important proactive step to enhance the uptake of future vaccines. The development of a powerful COVID-19 educational vaccine campaign based on local interventions is crucial. However, the effectiveness of vaccination programs must extend beyond the biological and immunological benefits to include social, political, and community levels.

This study aimed to recognize and understand the obstacles and facilitators in accepting a potential COVID-19 vaccine among medical students in Yemen. This is to help prepare for issues surrounding the public acceptance of the vaccine. To establish an evidence-based approach, we must first consider hesitancy and acceptance of the COVID-19 vaccine.

This will allow healthcare professionals to establish messaging that will best address concerns and educate the public.

Materials and Methods

Ethical approval and Informed consent

This study was approved by the institutional review board of the Faculty of Medicine of Al-Hikmah University (Approval number: HU20/10033). Informed consent was obtained from all participants before the interview.

Study period and location

The study was a qualitative analysis focused on open-ended questions conducted between August 1 and September 29, 2020. This study conducted among medical students at Faculty of Medicine, Al-Hikma University, at Sana'a in Yemen.

Site selection

The Faculty of Medicine at Al-Hikma University was selected for this study. It is a private university located in the capital city of Yemen, Sana'a. Medical students were asked to explore their views on their willingness to receive a future COVID-19 vaccine. This group was selected because healthcare workers should safeguard patients and thus promote vaccine acceptance by providing more facts and details about the issues related to the vaccine.

Study design

Thirty medical students agreed to participate in this study. So, to achieve data saturation, we used 20 students in our study. A qualitative design was used to capture more details and fully address the study questions. To ensure saturation of the themes related to barriers and acceptance of vaccination, the participants were interviewed until no new themes appeared. Students were enrolled until additional interviews revealed no new ideas, that is, theoretical saturation.

Study tool

To better understand the underlying factors that affect acceptance of the COVID-19 vaccine, the corresponding author conducted a qualitative exploratory study with open-ended questions. All the interviews were conducted by a professional interviewer. The interviews were conducted on the university campus.

The purpose of the study, how to use the question guides, and research ethics were explained to participants. On average, the interviews lasted between 30 and 60 min. The files were translated from Arabic into English at the end of each interview day. Random quality checks of translations and transcriptions were conducted by a bilingual expert. The investigators read the transcribed files regularly to ensure that data collection remained on track with the study goal. Open-ended questions assessed the participants' concerns about vaccination. General questions such as "How do you feel about the future COVID-19 vaccine?," "What do you see as the benefits of COVID-19 vaccine?," and "What do you see as the risks of future COVID-19 vaccines?" were asked.

Statistical analysis

The data were transcribed and analyzed using grounded theory. The standard technique for coding was used, and coding was entirely based on the content of the interviews. A final code was developed, which served as a reference for the subsequent data analysis.

Two researchers often read the transcripts separately to identify the initial concepts and patterns related to factors that may encourage and discourage vaccine uptake. The same two researchers coded the data separately by highlighting words, phrases, and sentences, which were then checked together to arrive at the final collection of codes.

One investigator removed the highlighted sentences from the transcripts that outlined the participants' responses. The codes were grouped

into larger categories, resulting in a collection of themes (Table-1). The two investigators collaborated to revise these themes to ensure that they adequately addressed the research questions. The first author identified the key characteristics and made the final interpretation of the dataset at the end of the research.

Results

The majority of the participants were female because they were more responsive to invitations than males. Participant ages ranged from 21 to 29 years (Table-2). The majority of participants agreed that they would take a future COVID-19 vaccine. This was to protect themselves, their families, and others. Others shared that it is important to stop the virus from spreading and that this vaccine is just as important as any other routine vaccination.

Table-1: Emerging themes about the acceptance and barriers of COVID-19 vaccine.

Emerging Themes	Quotations sample (Against vaccination)
Trusting God	"For me, it's impossible to get vaccinated. There just needs to be trusting in ALLAH, COVID-19 was created by God and I think the vaccine is not bad but I prefer to trust my beautiful and optimistic white blood cells. The advantage of vaccination is to create a memory for the virus so when it attacks us our body is ready, but I prefer to increase my immunity to fight this virus" "life and death is God's job, the effectiveness of the vaccine is very weak. Doing the prevention measures is better than vaccination such as physical distance, eating healthy food, and consuming herbs that contain vitamin C. These are very useful for protection" "I'm not taking it because I believe in God, and then I will take all the necessary precautions to protect myself from this virus"
Increase immunity	"Allah gives us the month of fasting [Ramadan] and the prophet advised us to fast three days each month. It's supported by scientific research that fasting may strengthen the immunity" "I prefer to improve my immunity through natural ways with a healthy lifestyle such as exercise, less stress, eating more fruits and vegetables, getting enough sleep and practicing good hygiene"
It is a simple disease	"I am against taking the vaccine because the causes and symptoms are very simple and it's not that dangerous, the real threat is among the elderly, who could die. Prevention from the coronavirus is very simple, you just need to strengthen your immune system"
Feeling fit	"I'm not taking the vaccine as I can increase my exposure to the morning sun, which increases my immunity, along with more exercise, relaxation and taking more fruits and vegetables"
It is about business but not about the vaccine	"There is much news that there is a competition between China, the USA, England and Russia and others to produce the best vaccine. Their objectives are to promote their vaccine for money sakes and not for the vaccine"
Prevention is better than cure	"Since the prevention measures can be better than the vaccine, I am not going to take it, because vaccines are secondary things for me"
Efficacy	"If I take the vaccine we may protect ourselves for a limited time"
Rushed manufacturing	"I am not accepting this vaccine because it has taken a very short time to be produced and pharmaceutical companies are competing in a rushed and very quick way"
Virus protection from the previous infection	"Previously I was infected with the coronavirus; therefore, I am protected and have immunity from any new coronavirus infection. I decided not to take it because I got infected with COVID-19 and I think I am fully protected"
Afraid of needles	"I'm not taking it because I am afraid of needles"
Not Halal	"I'm not taking it because it may contain some ingredients from pigs or alcoholic products and it's not Halal" "The Chinese vaccine involves animals like pigs and dogs as an experiment, and the Russian vaccine contains alcohol" "If the vaccine is developed by the Islamic countries I will take it if it's from Europe, I prefer not to take it"

(Contd...)

Table-1: (Continued).

Emerging Themes	Quotations sample (Against vaccination)
Will affect human DNA	"There is much doubt about this vaccine which will affect human DNA. I am not going to accept it before there is enough time to wait and see the side effects" "This vaccine will change our DNA forever...they are using RNA to rewrite our DNA per a statement made by Gates"
Safety	"If it is tested clinically and its safety is proven, I will get it" "It's possible that my body cannot tolerate the vaccine, and that may make me sick or even die" "I am not taking it because it may cause other health problems. Nowadays, a lot of fake information is spread through a variety of media. The vaccine may benefit some and certain people but not all" "I am against this vaccine because it may have more harm than benefits and affect our health more than the effects of the virus itself"
Lack of knowledge	"I refuse to get this vaccine because I don't know anything about the vaccine, its safety and side effects"
Affects fertility and aimed to reduce the planet population	"This is not a vaccine, this is a toxin to reduce the elderly population, sick people and those who are a burden on the world economy" "As I heard, it affects human fertility, and can make changes in human DNA"
Emerging Themes Protection	Quotations sample (with vaccination)
The vaccine is good and tested	"The COVID-19 vaccine is now been developed by many companies in developed countries, it should be safe because it will be tested on animals such as monkeys, mice, and then tested on some individual volunteers" "Yes, I will take the vaccine if tested and approved in order to stop the spreading of coronavirus and to keep our family safe" "Yes, I agree if this vaccine is tested with high efficiency and no side effects" "Yes, I agree if this vaccine is tested for all races and different cultures because it may be more effective for one certain race than another race"
It is like the routine vaccination	"We will take it as if it's a basic vaccine that is given to us in childhood" "Yes, I agree to be vaccinated because the history of medicine has shown that vaccines can prevent many diseases globally"
Perceived risk	"Because this virus is very dangerous, spreads very fast, infects millions of people through the world and may cause death. Therefore, I agree to take the vaccine" "Yes, I agree because COVID-19 is a dangerous disease that may cause death if not treated by professionals via proper medication. It would be a wise decision to take this vaccine"

Table-2: Age and sex of the study participants.

Variable	Category	Number
Age	21	4
	22	6
	23	3
	24	3
	25	3
	29	1
Gender	Male	8
	Female	12

Reasons for accepting the vaccine

Protection

A very important theme reported among the participants was protection, either protection of self or others, and to stop the further spread of the coronavirus, so it is possible to return to normal life. Most of the participants agreed that they would be vaccinated to protect themselves. One of the participants said, "We will take it because we want to protect ourselves and others and stop spreading the coronavirus further." Protecting others was also a concern reported among

the study participants. One of the participants said, "Yes, of course, I am willing to be vaccinated because I want to protect myself, my family, and my country. I would like to go back to our normal life, and then I can see my family. The vaccine can save many people's lives."

The vaccine is good and tested

Some of the study participants mentioned that any COVID-19 vaccine released by well-known companies would be good and would follow the standard regulation for development. One of them said, "The COVID-19 vaccine is now being developed by many companies in developed countries; it should be safe because it will be tested on animals first and then tested on individual volunteers." Some other participants explained that they would take a COVID-19 vaccine if it got approval from local or international authorities and had no side effects. One of them said, "Yes, I will take the vaccine if tested and approved in order to stop the spread of coronavirus and keep our family safe." Another participant said, "Yes, I agree if this vaccine is tested with high efficiency and no side

effects.” One participant raised a very important issue: The vaccine should be tested in all races and different cultural settings in order for it to be suitable for everyone on the planet. The participant said, “*Yes, I agree if this vaccine is tested for all races and different cultures because it may be more effective for one certain race than another race.*”

It is like the routine vaccination

Some participants reported that this vaccine is similar to any other routine vaccine that is trusted throughout human history, and that this vaccine is similar to any routine vaccine. One of them said, “*We will take it as if it is a basic vaccine that is given to us in childhood.*” Another participant said, “*Yes, I agree to be vaccinated because the history of medicine has shown that vaccines can prevent many diseases globally.*”

Perceived risk

Willingness to be vaccinated was also reported among participants who perceive that COVID-19 is very dangerous and could cause death. One of them said, “*Because this virus is very dangerous, spreads very fast, infects millions of people throughout the world, and may cause death. Therefore, I agree to take the vaccine.*” Another participant said, “*Yes, I agree because COVID-19 is a dangerous disease that may cause death if not treated by professionals via proper medication. It would be a wise decision to take this vaccine.*”

Reasons for hesitancy

However, some participants expressed hesitation about the future COVID-19 vaccine for the following reasons:

Trusting god

Three participants mentioned that they would never get the COVID-19 vaccine because they trusted God, and God is the one who created the COVID-19 virus and could protect us from it and the disease. God is the creator, and life and death are in God’s hands. One of them said, “*For me, it’s impossible to get vaccinated. It just needs trusting of ALLAH; COVID-19 created by God, life and death is God’s job, the percentage of the vaccine to be useful is very weak.*” Another participant stated that they believed in God and preferred to rely on their white blood cells and build immunity through Vitamin C, physical activity, and eating healthy food. One of them said, “*I think the vaccine is not bad but I prefer to trust my beautiful and optimistic white blood cells, the advantage of the vaccine is to have memory for the virus when it attacks us our body is ready, so I prefer to increase my immunity to fight this virus, doing the prevention measures is better than vaccination such as physical distance, eating healthy food and herbs that contain vitamin C, which is very useful for protection.*”

Fasting is better than vaccination

One of the participants preferred to practice fasting, especially during the holy month of Ramadan, three days in the middle of the Islamic calendar (13th, 14th, and 15th), because fasting probably strengthens immunity. The participant said, “*Allah gives us the month of fasting (Ramadan) and the prophet advised us to fast three days each month. It is supported by scientific research that fasting may strengthen the immunity.*”

It is a simple disease

Some participants believed that COVID-19 is a simple disease. Therefore, the perceived risk of COVID-19 is not considered important among those who refuse to take the COVID-19 vaccine. One of them said, “*I am against taking the vaccine, because the cause and symptoms are very simple and it is not that dangerous; the real threat is among who could die. Prevention from the coronavirus is very simple; you just need to strengthen your immune system.*”

Feeling fit

Some participants were unwilling to be vaccinated against COVID-19 because they were fit. One of them said, “*I am not taking the vaccine, as I can increase my exposure to the morning sun, which increases my immunity, along with more exercise, relaxation, and taking more fruits and vegetables.*”

It is about business but not about the vaccine

A few study participants speculated that this vaccine was created for business purposes, not for the vaccine. One of them said, “*There is much news that there is competition between China, USA, England, Russia, and others to produce the best vaccine. Their objectives are to promote their vaccine for money sakes and not for the vaccine.*”

Prevention is better than cure

Some participants shared that the reason they are not willing to be vaccinated is that they are practicing preventive measures against COVID-19. One of them said, “*Since the prevention measures can be better than the vaccine, I am not going to take it because vaccines are secondary things for me.*”

Efficacy

Some of the participants were worried about the efficacy of the COVID-19 vaccine and, therefore, were not willing to be vaccinated. One of them said, “*If I take the vaccine, we may protect ourselves for a limited time.*”

Rushed manufacturing

Some participants were concerned that the COVID-19 vaccine was being produced too quickly. One of them said, “*I am not accepting this vaccine because it has taken a very short time to be produced*

and pharmaceutical companies are competing in a rushed and very quick way.”

Virus protection from the previous infection

Several participants mentioned that they had been infected with the virus; therefore, they were protected. One of them said, “Previously, I was infected with the coronavirus; therefore, I am protected and have immunity from any new coronavirus infection. I decided not to take it because I got infected with COVID-19, and I think I am fully protected.”

Afraid of needles

One of the participants was unwilling to take the COVID-19 vaccine because of fear of needles. The participant said, “I am not taking it because I am afraid of needles.”

Not halal

Religious barriers were also reported by all participants. There was concern that ingredients from pigs and alcohol may be used in any of the stages of COVID-19 vaccine production. In addition, countries that developed the COVID-19 vaccine, such as Russia, are not practicing Islamic regulations. Therefore, some participants were unwilling to take this vaccine for religious reasons. One of them said, “I am not taking the COVID-19 vaccine because it may contain some ingredients from pigs or alcoholic products and it is not halal for Muslims.” Another participant said, “The Chinese COVID-19 vaccine involves animals like pigs and dogs as an experiment, and the Russian vaccine contains alcohol.” One participant mentioned that if an Islamic country developed the COVID-19 vaccine; they would take it. The participants said, “If the vaccine was developed by Islamic countries, I will take it, but if it is from Europe, I prefer not to take it.”

The COVID-19 vaccine will affect human DNA

Some participants raised concerns that this type of vaccine might change human DNA. One of them said, “There is much doubt about this vaccine which will affect human DNA. I am not going to accept it before there is enough time to wait and see the side effects.” Another participant said, “This vaccine will change our DNA forever. They are using RNA to rewrite our DNA per a statement made by Gates.”

Safety issues

Safety issues were also considered one of the main barriers among participants. Concerns raised during the study included that the vaccine may not be tested properly, their bodies may not tolerate the COVID-19 vaccine and it may make them sick or even die, and that this vaccine may cause more harm than good. One of them said, “It is possible that my body cannot tolerate the vaccine, and that may make me sick or even die.” Another participant said, “I am not taking it because it may cause other health problems. Nowadays, a lot of fake information is spread

through a variety of media. The vaccine may benefit some and certain people, but not all.” Another said, “I am against this vaccine because it may have more harm than benefits and affect our health more than the effects of the virus itself.”

Lack of knowledge

Some participants did not know much about this vaccine; one said, “I refuse to get this vaccine because I do not know anything about the vaccine, its safety, and side effects.”

Affects fertility and aims to reduce the planet's population

Some participants believed that this vaccine is created to harm humanity. One of them said, “This is not a vaccine; this is a toxin to reduce the elderly population, sick people, and those who are a burden on the world economy.” Another participant said, “As I heard, it affects human fertility and can make changes in human DNA” (Table-1).

Discussion

COVID-19 vaccination is crucial in controlling the COVID-19 pandemic and bringing an end to social distancing and economic crises. Many drug companies and research centers worldwide are working to develop vaccines. However, the success of overcoming this pandemic relies on the public acceptance of the vaccine.

The determinants of vaccine hesitancy are complex and can be attributed to socio-cultural and political factors. In addition, there are personal factors such as reservations about the need for vaccination, vaccine safety, fear of potential adverse events, myths about vaccine safety and effectiveness, prior negative experiences, religious concerns, and mistrust of the vaccine industry and healthcare system that prevent individuals from taking the vaccine [14,18].

The majority of participants in this study showed a willingness to be vaccinated with the COVID-19 vaccine. Our findings are consistent with those of studies conducted in China and the United States, which reported acceptance rates of 72.5% and 80%, respectively [19,20]. Similar observations were made during the H1N1 pandemic [21].

The reason for the high acceptance rate in our study could be due to the fact that the participants were medical students with better knowledge compared to the general population. Since healthcare professionals have a more in-depth understanding of COVID-19, they are more likely to protect themselves and not spread the virus to their family members. As a result, they are more likely to consider the vaccine than those working in non-medical fields.

Healthcare workers may also experience a higher level of risk than non-healthcare workers. In addition, healthcare professionals who have direct and regular contact with patients play an important role in sustaining

vaccine interest and are regarded as the most trustworthy sources of information for patients [22,23].

Previous studies have found that healthcare workers are more supportive of COVID-19 vaccines than non-healthcare workers, likely due to self-protection issues and a willingness to protect families, friends, and patients [24,25]. Previous studies have also shown that a high level of knowledge is a positive indicator of vaccine uptake and vaccine acceptability [26,27].

With the increasing availability of new vaccines, it is a challenge for these professionals to keep updated with the latest recommendations. They need to be aware of the signs and symptoms, precautions, and likelihood of adverse effects.

Furthermore, they are vulnerable to contracting and transmitting infectious diseases because of their work environments. It is important to be ready to respond to vaccine-related public concerns; however, it is also critical to understand the difficulties that healthcare workers face when dealing with this issue.

Healthcare professionals' vaccination knowledge and personal trust in vaccines are important factors that come into play when recommending vaccines to patients [28,29]. The overall positive attitude toward COVID-19 vaccination and the broad perceived pandemic effects may explain the acceptance of COVID-19 vaccination among this study group. The participants were able to see significant benefits from vaccination, which increased vaccine acceptance.

Participants who accepted routine vaccination were willing to receive the COVID-19 vaccine in the future. In other studies, those who had previously accepted vaccination were more likely to consider future vaccines [27,30]. Prior immunization programs have been linked to a higher degree of trust in the health system [31]. In areas of infectious disease outbreaks, high-risk awareness is converted into proactive behavior with improved infection control [32].

The vaccination rates were higher among participants who felt a greater sense of professionalism in protecting their patients. As a result, future campaigns should recognize and encourage the value of being a role model and emphasize the importance of their own vaccination in protecting the health of their patients. Although a high acceptance rate was observed in this study, some participants reported barriers to vaccination.

Some participants said they would refuse or would be reluctant to take a future COVID-19 vaccine. The reasons given by the participants were lack of knowledge, safety concerns, and feeling fit and healthy, feeling the vaccine is being manufactured in a rushed way, having strong immunity already, feeling that the vaccine must be approved by the World Health Organization (WHO) and the local Ministry of Health, having been previously infected with COVID-19 and believing their body is now protected, trusting God, and believing they have the ability to

increase immunity naturally by fasting. As this is a new vaccine and has never been known or used before, there is uncertainty about its uptake, which appears to be spreading.

Similar results were reported in France, where 26% of respondents said they would not like to take a potential COVID-19 vaccine [17]. According to a recent study, 12% of participants said they would not take the COVID-19 vaccine, and 82% said they would not take it because of side effects [33]. Social media could be a major factor discouraging people from getting vaccinated, and exposure to vaccine-critical media was found to have a determining effect on immunization intention [34]. Many vaccine-related misinformation is spread through social media, which is harmful, particularly for populations with low health literacy.

In this study, the participants mentioned that lack of knowledge was one of the main barriers to vaccination. Educating medical students and healthcare professionals on recognizing and treating infectious diseases that are preventable through vaccination is vital to ensure that they provide recommendations and improve the uptake of vaccination for disease control. A previous study found that medical students were unable to properly discuss aspects of vaccine refusal with their parents [35].

Studies that support our findings demonstrate a lack of vaccination awareness and training in the medical practice, especially when it comes to addressing vaccine adverse events, healthcare professional vaccination, and strategies to cope with vaccine refusal [36,37]. A survey of pediatric residents in the United States found that most residents were worried about coping with parents who rejected vaccines, which is also consistent with our findings. More than 95% of pediatric residents said they would benefit from additional training in this field [38]. This may be due to the insufficient teaching regarding vaccinations in medical schools. Therefore, there is an urgent need to include vaccine modules at all medical schools to prepare students with excellent vaccine knowledge.

The participants in our study raised concerns over vaccine safety issues and considered it the main issue for future COVID-19 vaccine acceptance. Vaccine safety issues have been a concern for the general public since the development of the first vaccine. For instance, in a previous study on the human papillomavirus (HPV) vaccination program, nurses considered the safety of the vaccine as one of the significant considerations when deciding whether to recommend it [39]. The participants in a previous study raised concerns about the vaccine being rushed into production. This question about the efficacy of the vaccine is comparable to the results from the H1N1 2009 pandemic, in which non-uptake was linked to the assumption that the vaccine had not been thoroughly tested and was rushed into circulation [40,41]. The previous studies identified questions regarding side effects, vaccine effectiveness, and vaccine safety as barriers [42,43].

Given the rapid production and testing process, latent mistrust of vaccines among segments of the population, and mistrust of the government's pandemic response, vaccine safety is almost certainly a major concern. Therefore, vaccine safety issues should be addressed before and during the implementation of vaccine programs.

The public should be aware of the rigorous process of vaccine testing and continuous monitoring that the vaccine approval process necessitates. It is also important to undertake local educational programs that provide knowledge on how individual vaccination contributes to herd immunity.

Greater transparency in vaccine efficacy and adverse effects may increase public confidence in COVID-19 vaccines. However, messaging needs to be cautious to avoid unintentional exaggeration of the risk of unusual adverse events. In a survey of over 1000 adults in the United States, 9% considered the vaccine to be unsafe [44]. According to another study, up to a third of Americans would refuse to receive the COVID-19 vaccine even though it was widely available and affordable [45].

Misconceptions regarding vaccination, such as safety and efficacy issues, fear of side effects and long-term implications, have all been identified as barriers to vaccination [46,47]. The 2009 influenza pandemic has raised concerns regarding vaccines [48]. Accurate knowledge of vaccine efficacy and safety can help alleviate these concerns and ultimately increase vaccine acceptance.

Another common misunderstanding among medical students is that COVID-19 affects fertility. Concerns about promiscuity and infertility following HPV vaccination were raised in a previous study [49]. There was no indication that women who received HPV vaccine reported an increase in infertility. These findings contribute to the body of evidence supporting the safety of the HPV vaccine, giving clinicians more confidence in recommending it to patients [50].

Another obstacle to COVID-19 vaccination among the participants was feeling fit and healthy. Participants who found themselves to be fit and healthy did not want to be vaccinated.

These individuals believed themselves to be at a low risk of infection. This is consistent with a previous study, which found that predicting a low infection risk is linked to a lower willingness to get vaccinated [51]. During the previous H1N1 pandemic, the research found that most people believed they were at low risk of contracting the virus [15,41].

This suggests a misconception that vaccine adoption is motivated by personal gains. The key advantages of vaccination have been described as personal protection, as well as protection of family and friends. As a result, future campaigns should put greater emphasis on personal benefits. A small number of participants said that the COVID-19 vaccine was more about money than health.

Respondents with vaccine hesitancy appeared to strongly believe that the natural development of the immune system is more important than artificial intervention. Similar findings reported in a previous study found that parents preferred that their child's immune system develop naturally because they were uncertain about the adverse effects of the vaccine [52]. In addition, there appears to be a trend of believing that good health can be achieved by maintaining bodily balance and naturally gaining immunity, especially among well-educated parents in Europe and the United States [53]. A previous study found that parents who believe in holistic well-being, natural childbirth, and breastfeeding increasingly question immunization [54]. Several mothers argued against the measles, mumps, and rubella vaccination by stressing the importance of gaining natural immunity through proper nutrition [55,56].

Our findings are in line with those of previous research, which found that prior and routine vaccination history plays an important role in embracing COVID-19 vaccination [41,57-59].

Some participants in our study mentioned that fasting could increase immunity, and they believed that intermittent fasting could improve the immune system in the long run. However, fasting might not be a good idea during an acute pandemic, when the immediate risk of infection is higher than normal, due to the risk of a temporary decline in immunity.

It is not true that vaccines are manufactured to minimize the global population. Vaccination has significantly lowered the burden of infectious diseases [60]. Vaccines have an outstanding safety record, and most vaccine panics have been proven to be false alarms [61,62]. Despite the undeniable progress of vaccination programs against formidable diseases that are currently scarce in developing countries, vocal anti-vaccine lobbies thrive today [63].

Vaccine safety has attracted more media interest than vaccination efficacy; however, the WHO has shown that vaccines are much safer than therapeutic drugs [63]. In the literature on healthcare trust, religious and ethnic minorities are commonly listed as having lower levels of trust in the healthcare system and practitioners [64-66]. This scepticism stems from past mistreatment and systematic neglect of these groups by governmental and systemic health [67,68].

Some participants thought that this vaccine would forever change their DNA using RNA to rewrite it. This is similar to what occurred in California, where anti-vaccine protesters carried posters to protest against the lockdown. Furthermore, a YouTube video that spread wild conspiracy theories about the pandemic claimed that vaccines would kill millions of people and received over eight million views. Although anti-vaccine groups are small, their online communication strategies are effective. According to the WHO, this argument is incorrect from a scientific perspective. A DNA vaccine involves the

direct introduction of a plasmid containing the DNA sequence (encoding the antigens to which an immune response is sought) into suitable tissues and relies on *in situ* development of the target antigen. In contrast to the more widely used conventional vaccines that use a whole pathogen or fragment, a DNA vaccine requires injecting a small portion of the virus's genetic code into a patient to stimulate the immune response.

The following is how some participants summarized their vaccine concerns “*I am not taking it because it may contain some materials from pigs or alcoholic products, and it is not halal.*” The use of animal ingredients, especially pigs, in vaccine production is a major concern for approximately 2 billion Muslims worldwide and needs to be addressed. Several studies have established religion as a common barrier to vaccination in many countries [69,70].

In several Muslim countries around the world, Muslims have refused immunization because vaccinations are non-halal [71]. Religious leader influence has been reported as an effective strategy for increasing vaccine acceptance [72]. In Ireland, independent politicians may be key figures in communicating the value of the COVID-19 vaccination. Consequently, early and regular involvement of religious and community leaders and cooperation between health agencies is important to avoid the impression that leaders are working exclusively on behalf of government authorities [73,74].

A lack of trust in the healthcare system is a strong barrier to vaccination. Institutions' mistrust has also been identified as a cause of vaccine hesitancy in Europe and certain parts of Africa [75,76]. In a previous study, mistrust was reported as a major barrier to vaccination [75].

Participants in this study stated that a lack of knowledge is an obstacle to COVID-19 vaccination, and that more information about the COVID-19 vaccine and how it works is required. There is also a need for more education for healthcare professionals to have appropriate knowledge and address any questions that patients may have. This suggestion has been documented in previous studies [77,78]. It has been shown that vaccine trust is linked to public awareness of infectious diseases [79].

A global study found that countries with successful public awareness programs against different infectious diseases had very high rates of consensus on vaccine safety and efficacy [80]. The media's distribution of vaccination information affects people's decisions on whether to vaccinate. Parents who do not know enough about vaccine-preventable diseases may have negative attitudes toward vaccinations and healthcare providers [81,82].

Limitations

The strength of this study is that it is a qualitative design that used in-depth interviews to delve into the feelings and sensitivities of medical students and

their perceptions about the COVID-19 vaccine. This is an important and timely issue, particularly during the COVID-19 pandemic. Therefore, it is critical to address vaccine misconceptions.

Another significant strength of this study is that it is the first study in Yemen to focus on the hesitancy of the COVID-19 vaccine. However, its limitation included students from only one medical school, and further studies are recommended among other medical schools and different groups of the general population.

Conclusion

Our results can be used to establish a successful vaccination plan for individuals in this country who refuse the COVID-19 vaccine. Details regarding vaccine safety should be made publicly available at regular intervals. In addition, timely health education and communication from reliable sources, including healthcare professionals, are crucial for easing public concerns about the vaccine.

Recommendations

The implications of COVID-19 on health and economic, emotional, social, and environmental issues should be highlighted. Furthermore, the provision of accurate information on vaccine efficacy and safety could help alleviate these concerns. COVID-19 vaccine refusal issues must be addressed to ensure a high degree of vaccination uptake.

Authors' Contributions

RAA: Conception, design, data analysis, data collection, and writing. HA: Design, writing, referencing, revising, and editing of the manuscript. RRA: Review and editing. SM: Review, editing, and proof-read. All authors have read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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