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LEADING INTERNATIONAL VACCINOLOGY EDUCATION (LIVE)

Assessing COVID-19 vaccine acceptability in the general public, especially adults and elderly, in Oman

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Abstract

Background

The novel COVID-19 disease has overwhelmed the world since 2019, leading to a dramatic loss of human lives worldwide. Vaccination is considered a key strategy to control the COVID-19 pandemic. Thus, successful vaccination programs depend on vaccine availability and acceptance by a large proportion of the population. This study aims to understand how the COVID-19 vaccine will be accepted by the general population of Oman.

Methodology

A cross-sectional study was conducted using a structured and validated online questionnaire. Adults and elders residing in Oman were invited between 22nd to 25th of December 2020 to participate in this study.

Results

A total of 966 participants took part in this study. The knowledge of COVID-19 cases in the country (946; 97%) and the international COVID-19 vaccine development (831;86%) among the participants was high. However, only 27% (265) of participants were willing to get the COVID-19 vaccine but38% (365) were not sure and 35% (336) would not accept the vaccine. The main determinant of COVID-19 vaccine acceptance was to protect themselves and the people around them (70%). Participants mentioned side effects (72%), vaccine safety issues (55%) and vaccine ineffectiveness (15.3%) as the main reasons for hesitation.

Conclusion

A significant level of COVID-19 vaccine hesitancy was found. Participants' perceived risk and trust in vaccines, government and their health system were found to be significant predictors for vaccine acceptance. Findings suggest the need to develop tailored strategies to address concerns identified in the study to ensure optimal vaccine acceptance among the general population in Oman.

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List of abbreviations

3Cs = Confidence, Complacency, Convenience
ACE 2= angiotensin-converting enzyme 2
ADS2A= Association for Scientific Dissemination and Associative Aid
AEFI= Adverse Events Following Immunization
ANOVA= Analysis of Variance
AOR= Adjusted odds ratio
ARDS= acute respiratory distress syndrome
CEPI= Coalition for Epidemic Preparedness Innovations
CoVs= coronavirus family
COVAX= COVID-19 Vaccines Global Access
COVID-19= Coronavirus disease 19
DNA= Deoxyribonucleic acid
EMA= European Medicines Agency
EMR= Eastern Mediterranean region
EPI= Expanded Program on Immunization
GCC= Gulf Cooperation Council
HCW= Health Care Workers
IMST= Incident Management Support Team
KAP= knowledge, attitude, and perception
LRT= lower respiratory tract
MERS= Middle East Respiratory Syndrome
MoH= Ministry of Health
mRNA= *Messenger RNA*
NESI= Network of Education and Support in Immunisation
N.P.G= National Pharmaceutical Group
OR= odds ratio
PCA= Principal Component Analysis
RO= reproductive value
RNA= Ribonucleic acid.
***SAGE*=** Strategic Advisory Group of Experts
SARS-COV-2= severe acute respiratory syndrome coronavirus 2
ssRNA= positive single-stranded RNA
URT= Upper respiratory tract
VPD= Vaccine-preventable diseases
WHO= World Health Organization

Contents

Chapter 1

Bibliographic introduction on assessing COVID-19 vaccine acceptability among the general population, especially adults and elders, in Oman.

1 The Coronavirus disease 19 (COVID-19)

1.1 The virus (SARS-COV-2)

The novel coronavirus disease (COVID-19) caused by the virus SARS-CoV-2 is part of the coronavirus family (CoVs), which over the past two decades have been associated with significant disease outbreaks. The more severe were in East Asia with SARS (SARS-CoV-1) and in the Middle East with Middle East Respiratory Syndrome (MERS) [1]. SARS-CoV-2 is an enveloped β-coronavirus with a positive single-stranded RNA (ssRNA) approximately 30 kb in length, and a genetic sequence very similar to SARS (80%) and bat coronavirus RaTG13 (96.2%) [2][3]. The viral envelope is coated by spike (S) glycoprotein, envelope (E), and membrane (M) proteins. Host cell binding and entry are mediated by the S protein. The first step in infection is virus binding to a host cell through its target receptor. The S1 subunit of the S protein contains the receptor-binding domain that binds to the peptidase domain of angiotensin-converting enzyme 2 (ACE 2). In SARS-CoV-2 the S2 subunit is highly preserved which mediates the fusion of the viral and cellular membrane and it is also considered as a potential antiviral target [2]. Because of the role S protein plays in binding to target cells and cellular entry, it is of particular focus for vaccine designs. The virus structure and replication cycle are illustrated in figure 1. Upon entry into alveolar epithelial cells, SARS-CoV-2 replicates rapidly and triggers a strong immune response that in some severe cases might result in cytokine storm and pulmonary tissue damage.

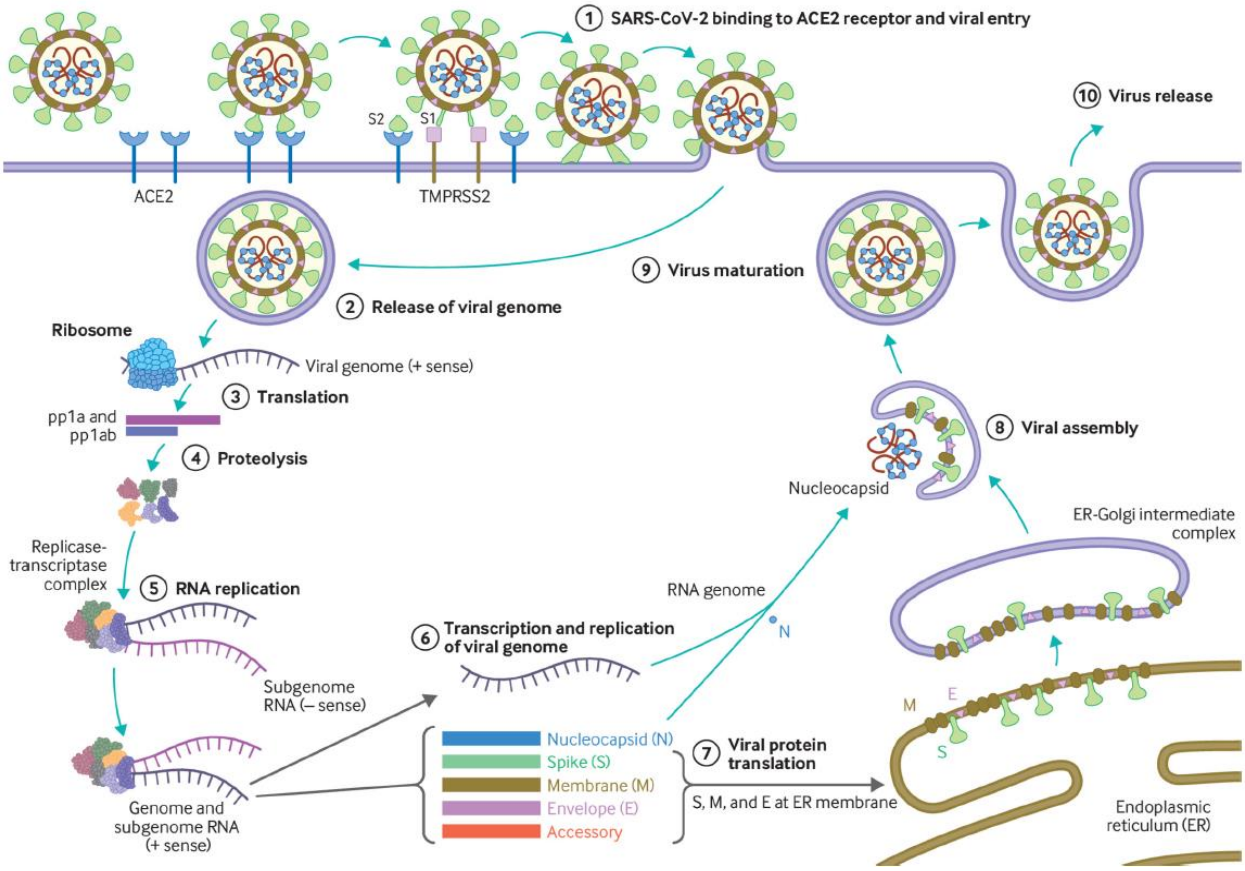

Fig 1. The virus binds to ACE-2 as the host target cell receptor in synergy with the host's cell surface protein, which is principally expressed in the airway epithelial cells and vascular endothelial cells. This leads to membrane fusion and releases the viral genome into the host cytoplasm. Stages (3-7) show the remaining steps of viral replication, leading to viral assembly, maturation, and virus release. ***Source****: Cevik, Muge, et al. "Virology, Transmission, and Pathogenesis of SARS-CoV-2." BMJ, vol. 371, Oct. 2020, 2.*

The cytokine storm leads to uncontrolled production of pro-inflammatory cytokines causing acute respiratory distress syndrome (ARDS) and multiple organ failure [4]. In addition to that, the numbers of total $CD4^+$ T-cells and $CD8^+$ T-cells are decreased in patients with SARS-CoV-2 infection and the surviving T-cells are functionally exhausted suggesting a decreased immune function in SARS-CoV-2-infected patients. Finally, the combination of ARDS decreased immune function and secondary infection worsens the respiratory failure. [5]

1.2 Transmission dynamics of SARS-CoV-2

Like other coronaviruses, the primary mode of transmission of SARS-CoV-2 is via infected respiratory droplets, which occur through direct or indirect contact with the oral, nasal, or conjunctival mucosa. Initially, the virus enters the upper respiratory tract (URT) invading the nasal and throat tissue and causes symptoms like the common cold, headache, throat pain, runny nose, and fever. It is within the mucosal epithelium of the URT where primary replication is thought to occur by interaction with target receptors (ACE-2). Subsequently, SARS-CoV-2 invades the lower respiratory tract (LRT) by interaction with ACE-2 epithelial cells of the lungs. The membrane fusion occurs after the binding of SARS-CoV-2 S-protein to the ACE-2 receptor, thereby injecting the viral genome into the host cell. Besides, the conjunctiva and gastrointestinal tracts are also vulnerable to infection and can function as transmission portals. The risk of transmission depends on factors such as contact pattern, environment, host immunocompetence and socioeconomic variables. Most transmissions occur through close-range contact (such as 15 minutes face to face and within 2 m), and the spread is especially efficient within households and through gatherings. [2][3] It is worth noting that SARS-CoV-2 is more infectious than the previous coronavirus and has a higher reproductive value (R_O). Initially, WHO estimated the basic reproduction number for COVID-19 between 1.4 and 2.5, as declared on January 23rd, 2020. As for April 2020, the R_O was calculated in the EMR which ranged between 7.41 (Turkey) and 2.60 (Oman) [6]. The effective reproductive number (Rt) in Oman can vary. For instance, it was 2.1 (95% CI 1.8–2.1) at the start of April 2021 and decreased to 1.3 (95% CI 1.2–1.5) in mid-April 2021. This effect corresponds to the influence on several biological, socio-behavioural, and environmental factors. Nevertheless, efficient public health interventions aim to reduce the Rt to below 1 (herd immunity) [6] Finally, some characteristics of SARS-CoV-2 may also explain this enhanced transmission; for instance, although the angiotensin-converting enzyme 2 (ACE2) receptor interacts with both SARS-CoV-1 and SARS-CoV-2, the latter has structural differences in its surface proteins that allow for stronger binding to the ACE 2 receptor, with approximately 20 times more affinity than SARS-Cov-1 and therefore giving SARS-CoV-2 a greater efficiency in invading host cells. [2]

1.3 COVID-19 pandemic and global impact.

The coronavirus pandemic has overwhelmed the world since the first case was reported at the end of 2019 by the World Health Organization (WHO). The initial cluster of cases was linked to a wholesale food market in Wuhan, China, which presumably worked as a zoonotic source of transmission to humans [7]. The WHO officially declared the SARS-CoV-2 outbreak a Public Health Emergency of International Concern on January 30, 2020, right before being declared as a global pandemic on March 11, 2020. Thus, countries were urged to adopt strict social distancing and quarantine measures to avoid virus spread and to protect public health. Despite the international efforts to reduce the morbidity and mortality of COVID-19 at this point, May 28st, 2021, there are > 168 million confirmed cases and >3,400,000 deaths worldwide [8]. This highlights the importance of international cooperation and unified strategy against the COVID-19 pandemic, with vaccination being the most effective tool to control the outbreak. As of May 28th 2021, the evidence of the global effort is that sixteen vaccines have been authorized by at least one national regulatory authority for emergency use around the globe (Table 1)

2 Preventive Measures

2.1 Non-pharmaceutical interventions against COVID-19

Prevention strategies have become fundamental to reduce the coronavirus spread. Some of the ways to reduce infection include social distancing via stopping large public or private gatherings, massive testing, wearing masks and gloves, avoiding unnecessary travels, and using mobile phones for contact tracing. Additionally, it is important to maintain some personal hygiene strategies like regularly and thoroughly cleaning the hands with sanitiser or soap and water; to avoid touching the eyes, nose, and mouth and cover the mouth and nose with a bent elbow or tissue when coughing or sneezing; cleaning and disinfecting surfaces, especially those which are regularly touched, such as door handles, faucets, and phone screens. Nonetheless, vaccination is considered to be the most effective and fundamental strategy to reduce the morbidity and mortality of COVID-19. [9]. Collectively, the aim of employing these preventive measures is to facilitate the management of the early onset of cases, to reduce the chance of further spread of the infection and to control the nosocomial infection.

2.2 COVID-19 vaccines development

The current COVID-19 pandemic has urged the international scientific community to find answers in terms of therapeutics and vaccines to control SARS-CoV-2. The Coalition for Epidemic Preparedness Innovations (CEPI) noted in September 2020 that nine separate technological platforms were used to develop an effective vaccine against SARS-CoV-2 using both, classical and next-generation approaches [10]. The classical platforms are Whole-inactivated virus, Live-attenuated virus, Protein subunit, and Virus-like particles. As for the next-generation platform, innovative strategies include Nucleic acids (RNA and DNA), Viral vectors (non-replicating and replicating), Recombinant protein and Antigen-presenting cells. The urgency to develop a safe and effective vaccine against COVID-19 has rapidly changed the future of vaccine science and the paradigm of what is possible in vaccine development. It is important to mention that the world was able to develop COVID-19 vaccines so quickly because of years of previous research on related viruses, next-generation vaccine platforms and faster ways to manufacture vaccines, enormous funding that allowed firms to run multiple trials in parallel and regulators moving more quickly than usual (Figure 2) [11].

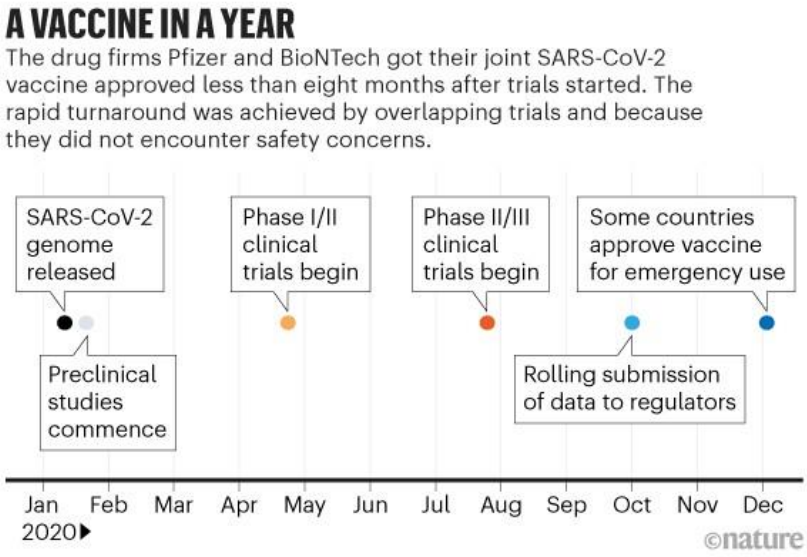

Fig. 2*.* Scheme of COVID-19 vaccine development compared with other vaccines in history **(A).** And timeline for COVID-19 vaccine development **(B).** *Source: Ball, P. (2021). The lightning-fast quest for COVID vaccines and what it means for other diseases. Nature* 589*, 16–18.*

As a result, on December 21, 2020, the European Medicines Agency (EMA) recommended granting conditional marketing authorisation for Comirnaty®; an mRNA-based vaccine that was recognized as an important milestone during this pandemic [12]. As to the date, May 1st, 2021, 14 vaccines have been authorized for emergency use around the globe (Table 1) [13]. Besides, 60 candidate vaccines are being tested in clinical trials on humans, 22 have reached the final stages of testing and at least 77 preclinical candidate vaccines are under active investigation on animals [14]. Besides, initiatives like the COVID-19 Vaccines Global Access (COVAX) lead by the WHO, CEPI, and Gavi, the Vaccine Alliance are promoting a fair and equitable distribution of COVID-19 vaccines for all countries. [9]

Tab.1 List of COVID-19 vaccines emergency authorized around the globe at the date, May 1st, 2021.

NAME	*VACCINE TYPE*	*PRIMARY DEVELOPERS*	*ORIGEN*	*EFFICACY*	*DOSAGES*	*STORAGE*
1. COVID-19 Vaccine AstraZeneca (AZD1222)	Viral vector (Ad) vaccine	BARDA,	UK	original virus: 60%-90% B.1.1.7: Same efficacy B.1351: Reduced efficacy P.1: Same efficacy	2 doses (12 weeks apart)	+2-8 ˚C = 6 months.
2. Covaxin	Inactivated vaccine	Bharat Biotech, ICMR	India	Original virus: 81%	2 doses (28 days apart)	+2-8 ˚C
3. WIBP-CorV	Inactivated vaccine	Wuhan Institute of Biological Products; China N. P.G. (Sinopharm)	China			
4. BBIBP-CorV	Inactivated vaccine	Beijing Institute of Biological Products; China N. P.G (Sinopharm)	China	Original virus: 79%	2 doses (21 days apart)	+2-8 ˚C
5. CoronaVac	Inactivated vaccine (formalin-alum adjuvant)	Sinovac	China	Original virus: 50% B.1.1.7: Same efficacy B.1351: Reduced efficacy P.1: Same efficacy	2 doses (14 days apart)	
6. Comirnaty (BNT162b2)	mRNA-based vaccine	Pfizer, BioNTech; Fosun Pharma	Multi-national	Original virus: 95% B.1.1.7: Same efficacy B.1351: Reduced Ab lev. P.1: Same efficacy	Dosing: 0.3ml- 2 doses (21 days apart)	-70˚C = 6 months. +2-8 ˚C = 5 days
7. Moderna COVID-19 Vaccine (mRNA-1273)	mRNA-based vaccine	Moderna, BARDA, NIAID	US	Original virus: 60%-90% B.1.1.7: Same efficacy B.1351: Reduced Ab levels P.1: Same efficacy	Dosing: 0.5ml- 2 doses (28 days apart)	-20˚C = 6 months +2-8 ˚C = 30 days
8. Sputnik V	Non-replicating viral vector (rAd26 and rAd5)	Gamaleya Research Institute, Acellena Contract Drug Research and Development	Russia	Original virus: 91%	0.5ml- 2 doses (21 days apart)	+2-8 ˚C = 6 months -20 ˚C= 2 years.
9. EpiVacCorona	Sub-unit Peptide vaccine	State Research Centre of Virology and Biotechnology	Russia			
10. Convidicea (Ad5-nCoV)	Recombinant vaccine	CanSino Biologics	China			
11. COVID-19 Vaccine JNJ-78436735	Non-replicating viral vector	Janssen Vaccines (Johnson & Johnson)	Netherlands, US	Original virus: 72%; B.1.1.7: Same efficacy, B.1351 and P.1: reduced efficacy	Dosing: single dose.	+2-8 ˚C = 3 months. -20 ˚C = 2 years.
12. CoviVac	Inactivated vaccine	Chumakov Federal Scientific Centre	Russia			
13. ZF2001	Recombinant vaccine (subunit)	Anhui Zhifei Longcom biopharmaceutical, Institute of Microbiology	China, Uzbekistan			
14. QazVac (QazCovid-in)	Inactivated vaccine	Research Institute for Biological Safety Problems	Kazakhstan	Efficacy of 96%	2 doses (21 days apart)	
15 Sputnik Light	Recombinant rAd26	Gamaleya Research Institute, CDRD	Russia	Efficacy 79.4%.		
16 Unnamed candidate	Inactivated vaccine	Minhai Biotechnology Co.; Kangtai Biological Products	China		2 doses	

Sources: Oakes, K., and Craven, J. COVID-19 vaccine tracker. Available at: https://www.raps.org/news-and-articles/news-articles/2020/3/COVID-19-vaccine-tracker [Accessed May 1, 2021]/ WHO, draft landscape and tracker of COVID-19 candidate vaccines https:/ [13]

2.3 COVID-19 vaccine safety and efficacy.

As described by the WHO on 31 March 2021, COVID-19 vaccines have been tested in large, randomized controlled trials that include people of a broad age range, both sexes, different ethnicities, and those with known medical conditions. The vaccines have shown a high level of efficacy across all populations and to be safe and effective for people with various underlying medical conditions that are associated with an increased risk of severe disease. However, in April 2021 there was a spike in discussions around some of the COVID-19 vaccines in relationship with side effects, like thrombopathy, that might impact vaccine confidence. As for pregnant women, there is very little data available to assess COVID-19 vaccine safety in pregnancy. Thus, the potential risk of severe maternal disease against the unknown risk of foetal exposure should be weighed carefully in order to correctly decide whether to accept the vaccine or not. [15] Nevertheless, a study done by Gray et al. (2021) showed that COVID-19 mRNA vaccines generated robust humoral immunity in pregnant and lactating women, with immunogenicity and reactogenicity like that observed in non-pregnant women and immune transfer to neonates, via placental and breastmilk [16]. It is worth mentioning that on 31 March 2021, Pfizer announced the first results for the COVID-19 vaccine in children. The vaccine had 100% efficacy and was well tolerated in phase III study on children aged 12 to 15 years old with and without prior COVID-19 infection. [17]

3 COVID-19 crisis in the Eastern Mediterranean Region (EMR)

After the outbreak began in China in late 2019, the virus spread within weeks to the EMR raising an evident need to take immediate action. This impelled the establishment of the official regional Incident Management Support Team (IMST) on 22 January 2020 just days before the first cases of COVID-19 were reported in the EMR. The IMST consists of the following eight pillars: Partnership and coordination; Health information management and surveillance; Health operations and technical expertise; International Health Regulations and points of entry; Operational support and logistics; Finance and administration; Research and knowledge management; and a Country support team that aims to bring together regional partners and authorities, facilitating effective operational response, tracking pandemic evolution, and evaluating and communicating outcomes [18]. On May 28th, 2021, WHO reported a total of 10,019,315 confirmed cases and 3,505,534 deaths in the EMR. Besides, Iran ranked as the 14th country with the highest COVID-19 confirmed cases in the world with 2,875,858. [19] Regionally, Iran ranked first and is followed by Iraq with 1,186,309 and Pakistan with 911,302 confirmed cases. Oman occupies the 15th position in the EMR with 213,784 cases and 2,303 deaths since the start of the pandemic [19]. Fortunately, vaccination campaigns have been running in nine countries in the region since January 2021, targeting high-risk groups including health workers, elders >60 years of age and people with pre-existing comorbidities. Moreover, on January 14th, Syrian refugees living in the Zaatari camp in Jordan were vaccinated, making Jordan one of the first countries to vaccinate refugees. By February 2021 over 2.9 million doses of various COVID-19 vaccines were administrated in the United Arab Emirates, Bahrain, Saudi Arabia, Oman, Kuwait, Jordan, Egypt, Qatar, and Morocco. An additional 46 to 56 million doses of AstraZeneca/Oxford vaccines are foreseen to be available during the first half of 2021 for people living in 20 of the EMR countries [20] (Figure 3)

Fig. 3 EMR member states. *Source: COVID-19 Pandemic Response in EMR Progress report [16]*

4 COVID-19 crisis in Oman

The first cases of COVID-19 were confirmed to have reached Oman on February 24, 2020, when two citizens tested positive after returning from Iran. On March 10, 2020, His Majesty the Sultan of Oman, Haitham bin Tariq Al-Said, gave orders to set up a Supreme Committee to implement appropriate steps to minimize the transmission of SARS-CoV-2 and any anticipated public and socio-economic impacts. The committee was chaired by the Minister of Internal Affairs and included different governmental sectors, principally, the Ministry of Health (MoH) of Oman. The response initiated by the MoH for COVID-19 prevention scaled up and aimed at strengthening the health emergency response systems, increase capacity to screen/detect and manage patients, ensure availability of adequate medical supplies and necessary personnel, and develop life-saving medical interventions [21]. These regulations also included the obligation to wear a mask and the use of sanitisers in public places extending to suspend classes, banning public gatherings, closing borders and places of worship, including mosques. During an e-press conference on April 9, 2020, the Minister of Health, Dr Ahmed al Saeedi, said, as per the directives of His Majesty the Sultan, *COVID-19 tests and treatment would be free for all communities in the sultanate with the goal to obtain the largest number of people to conduct tests* [22] Despite all the measures taken, by December 2020 in the country's cases reached up to more than 128,000. This highlighted the evident need for an efficient and immediate therapeutic method. As of May 28th, 2021, Oman has recorded 213,784 cases and 2,303 deaths [19]. The governorate of Muscat continues to be the most affected with the highest number of confirmed cases at over 108,000 and 727 deaths [23].

5 COVID-19, collateral effects of the pandemic in Oman

The emerging Covid-19 crisis has had a severe impact on all aspects of development in Oman. As in many countries worldwide, consumer spending has declined, travel and tourism have been disrupted, and industry has slowed down due to movement restrictions. Like other oil-exporting countries, Oman was affected by two simultaneous shocks: the global pandemic, and the drop in oil prices [24]. Besides, as in the other Gulf monarchies, a large percentage of Omani citizens are directly employed in the public sector, with the government able to ask them to stay at home and to receive support during the lockdown, thus helping to reduce the spread of the virus. However, for some non-Omani migrant workers, this option was not available as they had no access to the same government support, resulting in more than 160,000 expatriates leaving Oman during 2020. This may hamper future growth as non-Omani migrant workers represent up to 45% of the country´s population [25]. To counter this effect, Oman increased hospital capacity, the number of intensive care beds, medical supplies and mobilized human resources to serve its population. This included both Omani citizens as well as non-Omani residents, to whom the Government is extending its diagnostic and treatment coverage for COVID-19, free of charge. *The tests and treatment are free for all expatriates*, said Dr Ahmed Al-Saidi [26] On the other hand, Aseelah Al-Azri - Centre for Humanities Research mentioned how the pandemic affected various groups of society and the national economy. From the negative effects on the owners of small and medium-sized enterprises through those laid off from work, ex-pats who suddenly found themselves jobless and families in need of support, among others. Additional repercussions include the oversaturation of hospitals, closure of places of worship, recreation, sports centres, and lack of tourism. The suspension of education and confining employees to work from their homes counted as some of the most severe measures. [27] All these factors caused restricted movement of individuals and families resulting in, what seems to be, inevitable stressing repercussions. This will have effects not only in a political and socio-economical context but also individually on both physical and mental health.

6 Vaccine history, monitoring, and immunization coverage in Oman

The World Health Assembly in 1974 adopted a resolution and launched the Expanded Program on Immunisation (EPI). As a result of immunization, almost 3 million lives are saved each year, and 750,000 children are protected from disability worldwide. EPI in Oman was launched in 1981 with substantial progress during the next decades. The immunization coverage levels increased greatly from 10% in 1981 to over 95% in 1995. The near 100% coverage has been maintained since 2001, resulting in a great impact on vaccine-preventable diseases (VPD) [28]. The marked achievement in immunization coverage has resulted from an expansion of EPI to the grass-root level and its integration into the Primary Health Care services provided by the Ministry of Health (MoH) of Oman and the great collaboration and acceptability among the Omani population. Among the most significant regulations is worth mentioning the policy of the MoH to immunize all children under one year against the 10 vaccine-preventable childhood diseases namely: Tuberculosis, Diphtheria, Pertussis, Tetanus, Poliomyelitis, Measles, Hepatitis B, Rubella, Mumps & *Haemophilus influenzae* type b (primary immunization and boosters) and all the women of childbearing age with Tetanus toxoid. All these vaccines would be offered at all the MoH institutions, sister health organizations and vaccine qualified private clinics without incurring any cost to the beneficiaries [28] Besides, every child born was assigned a unique identifier, known as the MR2 number. Using this number, a child could receive immunization anywhere in the country. Additionally, an important implementation in the Omani vaccination program was the Cold Chain system which ensured the quality of vaccines from the time of production or arrival in the country until the individual is immunized. [28]. Finally, the surveillance of Adverse Events Following Immunization (AEFI), launched in Oman in 1996, has become a fundamental part of immunization programs addressing vaccine safety issues, effectively preserving the integrity of immunization programs, and increasing trust and acceptability in the Omani population [29].

Immunization Schedule (2019 or latest available)

Vaccine	Schedule
BCG	birth;
DT	6 years;
DTaPHibHepBIPV	2, 4 months;
DTwP	18 months;
DTwPHibHepB	6 months;
HepB_Pediatric	birth;
HIB	
Influenza_Adult	>60 years;
Influenza_Pediatric	
IPV	2, 4 months;
MenACWY-135 ps	
MMR	12, 18 months; >34 years;
OPV	4, 6, 18 months;
Pneumo_conj	2, 4, 13 months;
Td	12, 16 years;
Tdap	
TT	
Varicella	12 months;
VitaminA	12, 18 months;
YF	

Tab. 2 Immunization schedule in Oman, 2019. Source: WHO, and World Health Organization WHO| Oman, Immunization Country Profile.

7 Factors involved in Oman and the EMR vaccine acceptance.

7.1 General aspects for vaccine acceptance/hesitance.

There is no doubt that vaccination is one of the most effective public health interventions. Vaccination programs have contributed to the decline in mortality and morbidity of many diseases and are credited with the elimination of smallpox in 1971 and poliomyelitis in 1995 in Oman. [30] The high rate of vaccination coverage in most countries indicates that vaccination remains a widely accepted public health measure. However, these estimates may hide clusters of under-vaccinated or unvaccinated individuals. Indeed, many experts consider that vaccination programs are threatened by growing concerns among the population regarding the safety and usefulness of vaccines, and therefore reducing the acceptance of vaccination [31]. The WHO Strategic Advisory Group of Experts (SAGE) Working Group has defined this lack of acceptance as vaccine hesitancy [32]. For a better

understanding, the "3Cs" model: confidence, complacency and convenience has become a practical system to categorize vaccine acceptance/hesitance. **Confidence** involves trust in the safety and efficacy of the vaccines themselves, the reliability and competence of the health services and health professionals, and the motivations of policymakers who decide on the needed vaccines. **Complacency** refers to when the perceived risks of vaccine-preventable diseases are low, and therefore vaccination is not deemed a necessary preventative action. **Convenience** is measured by the extent to which physical availability, affordability and willingness-to-pay, geographical accessibility, ability to understand (language and health literacy) and appeal of immunization services affect the uptake. Many events have the potential to erode confidence in vaccines, therefore vaccine hesitancy is complex and context-specific, and it also varies across time and place (Fig. 4) [33]. The WHO has recognized some of the most prevalent reasons for vaccine hesitancy across all WHO regions, which have been a) risk-benefit (scientific evidence); b) lack of knowledge and awareness of vaccination and its importance; and c) religion, culture, gender, and socioeconomic issues. [34]

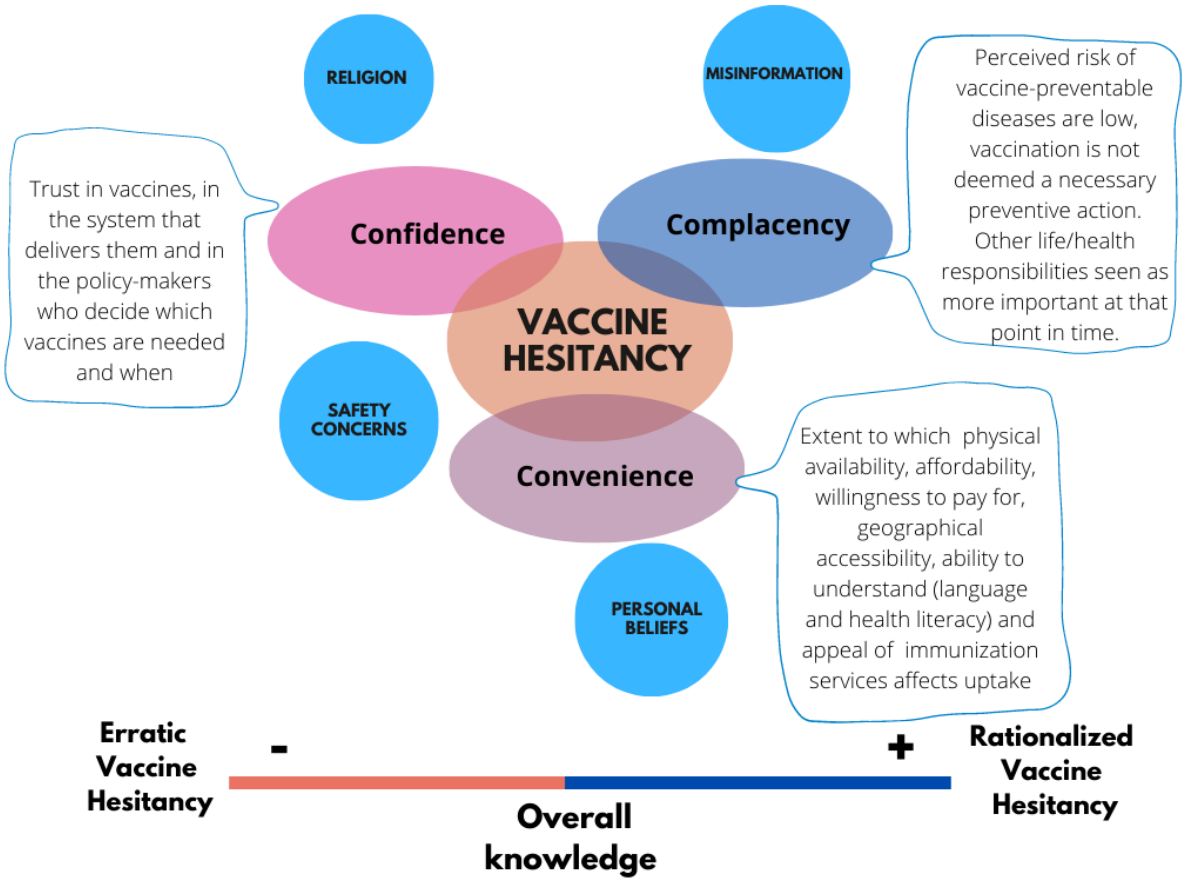

Fig. 4 Vaccine hesitancy "Cs" model, erratic or rationalized vaccine hesitancy and the influence of other determinants. (Modified from the SAGE report 2014 and The Association for Scientific Dissemination and Associative Aid (ADS2A)

7.2 Vaccine acceptance and immunization policies in Oman and the EMR

As previously described, Oman has a strong EPI program demonstrated by both the rapid decline of vaccine-preventable diseases in children and a coverage rate of routine vaccinations nearly 100% over the past ten years. Efforts in recent years have been focused on not only sustaining the achievements in childhood immunization but also enhancing adult immunization, particularly among health care workers and vulnerable groups. In line with this, the Eastern Mediterranean Vaccine Action Plan 2016–2020 highlighted the need of developing and updating policies, legislation, and regulations to commit the countries of the EMR to immunization as a priority especially regarding vaccination of adult age

groups [35]. As recently described in the study of Sauer, M. et al. (2021), based on the WHO Monitoring System Database, only 24% of the EMR Member States reported a national adult vaccination policy for influenza, 5% for pneumococcal disease, and less than 1% for zoster (Fig. 5) [36]. It is important to mention that the adult vaccination policies can be influenced by the relatively low morbidity and mortality of these diseases in the region [37]; the prioritizing of certain vaccines; the country wealth status; experience introducing new or under-utilized vaccines; and/or acceptability for vaccination among the population. Having said that, vaccination rates for diseases like influenza remain very low. As for 2015, in the EMR less than 20 doses of the influenza vaccine were distributed per 1000 people as compared to 45/112/275 in the Western Pacific, Europe, and Americas WHO regions, respectively [38]. The exact reasons for the low influenza vaccination rates when the vaccine is available and free are multifaceted and include misperceptions and erroneous interpretations of the efficacy and safety of the vaccine, and for the threat that influenza poses to health [39].

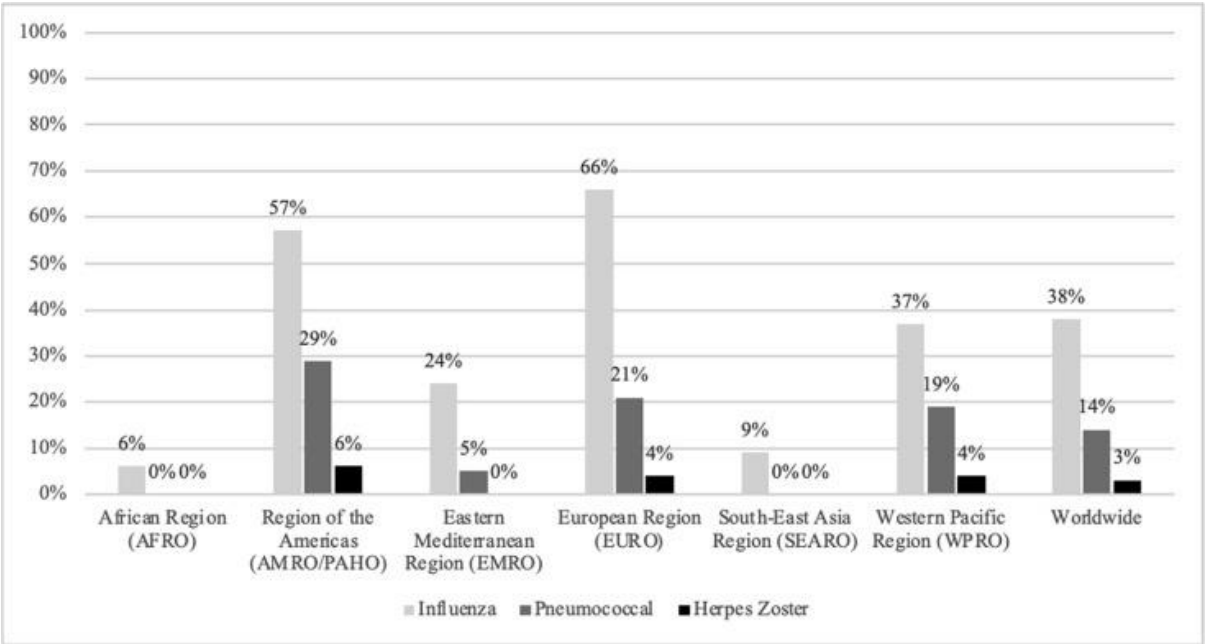

Fig. 5. Percentage of WHO Member States with national vaccination policies for influenza, pneumococcal disease, and varicella for individuals 15 years of age and older, 2017. *Source: Sauer, M. et al. (2021). Situational assessment of adult vaccine-preventable disease and the potential for immunization advocacy and policy in low- and middle-income countries. Vaccine 39, 1556–1564.*

Oman strives for 99% coverage in its universal influenza vaccine program for all Health Care Workers (HCWs). However, a study conducted by Awaidy, S.T.A. et al. (2020) reported that only 60% of the HCWs surveyed in the South Al Batinah governorate were vaccinated for influenza during the 2018–2019 season. This despite the availability of a free vaccine to all HCWs at their workplace in the country. The most frequently cited causes of hesitancy included fear of side effects (33.6%), fear of pain (12.6%), concerns regarding vaccine efficacy due to viral evolution (6.1%) and a lack of knowledge about influenza (6.1%) [39]. Thus, despite the health benefits of immunization against the influenza virus, misconceptions and doubts about seasonal influenza vaccines exist among HCWs. It is also important to recognize the main reasons for vaccine acceptance in this study: the need to protect themselves, those around them and their family (59.0%), high risk of exposure to infection (17.0%) and availability of vaccines (6.7%). Besides, some studies [36,37,39] support the notion that a lack of acceptance to receive the influenza vaccine by HCWs might also reduce their willingness to recommend the vaccine to their patients. This is important due to the high influence healthcare workers have over their patients, i.e. the advice from a healthcare provider was reported to be a driving factor for accepting the influenza vaccine by pregnant women in Pakistan [40]. These intercorrelated factors are important

to be understood as they resemble the current COVID-19 vaccination uptake and acceptance, not only for HCWs but also for the general population.

8 COVID-19 vaccine implementation strategy in Oman.

As a strategy to contain the spread, Oman started coronavirus vaccination on 27 December 2020, becoming the sixth Arab country and the last of the Gulf Cooperation Council (GCC) countries to begin inoculating people. Like most countries in the region, Oman opted for the mRNA-based Pfizer-BioNTec® vaccine [41] The first batch of the vaccines arrived on December 24, 2021, with more than 15,000 doses and having other shipments arriving gradually [42]. The second dose of the vaccine was given to the population after 21 - 28 days in different parts of the Sultanate. As of January 17, 2021, the minister of health Dr Ahmed Mohammed Al Sa'eedi reaffirmed, after receiving his second dose of the vaccine against COVID-19, that no side effects were reported among recipients of the first dose. The minister added that the factor that limits vaccination in Oman is not the financial cost or logistics, but the availability of the vaccine, which is part of a large global rush [42]. At the same time, the Health Affairs Undersecretary pointed out the efforts of the Ministry of Health in providing the COVID-19 vaccine, a situation that motivated Oman to cooperate with several vaccine-manufacturing companies and to join the COVAX facility co-led by Gavi, CEPI and WHO. By February 2021, Oman's Ministry of Health started inoculating citizens aged over 65 years with the Oxford-AstraZeneca vaccine, as reported in the daily Times of Oman. [43] The Ministry of Health of Oman divided vaccination into two stages. The technical team identified the target groups for taking the vaccine in the first phase which includes the elderly of 65 years of age and above, health care workers and people with chronic diseases. The Ministry of Health affirmed that the vaccine would not be mandatory. Uptake of the vaccine would be based on the conviction of individuals in the community about the importance of receiving the vaccine and would be supported by awareness and the promotion of a sense of responsibility and national duty. [44]

9 Research question. (COVID 19 vaccine acceptance in the general population in Oman)

As previously illustrated, immunization programs are successful only when there are high rates of acceptance and coverage. To accomplish this, it is critical to understand the population perceptions about COVID-19 disease, acceptance of a COVID-19 vaccine, and confidence in media sources, specifically those used to obtain information about the COVID-19 pandemic. Thus, it is important to answer this question: does vaccine acceptance/hesitancy play an important role to develop a valuable COVID-19 immunization strategy in Oman? The purpose of this study is to assess vaccine acceptance and hesitancy related to the COVID-19 vaccine. Thus, to analyse the knowledge, attitude, and perception of the general population (KAP) with aims to 1) predict COVID-19 vaccine acceptance using regularly available demographic information, 2) investigate the perceived barriers and facilitators of vaccine uptake among the general population and 3) provide information to develop immunization strategies for Oman population. Therefore, the importance of this study evolves within the international urge to develop efficient vaccination strategies as a response to the COVID-19 pandemic.

Chapter 2.

Methodology

The overarching aim of the study is to assess the COVID-19 vaccine acceptance among the general public in Oman. In this light, it is necessary to analyse the knowledge, attitude, and perception (KAP) based on the perspective of elders and adults regarding the COVID-19 pandemic and COVID-19 vaccines, using a customized questionnaire and cross-sectional quantitative method research.

1 Questionnaire design

After an extensive literature review on the COVID-19 pandemic, vaccination, and health policy globally, regionally and at a country level plus an effective discussion between Oman`s Ministry of Health and the team at Network of Education and Support in Immunisation (NESI), the questionnaire was developed. The goal was to assess the KAP of target populations previously mentioned using a questionnaire in Arabic and English, with understandable and impartial terminology and a well-organized structure. Subsequently, the questionnaire was entered and finalized in the survey tool © SurveyMonkey and distributed to the participants online via WhatsApp and email. This strategy was the most convenient due to several factors but mainly to stay socially distant during the pandemic. The questions were further classified into multiple categories: (A) Socio-demographic information; (B) COVID-19 awareness and perceived risk; (C) COVID-19 vaccine confidence and compliance and (D) preference and credibility of information sources. The choices of answer for most of the questions were limited to a 2-point scale: “1. Yes” and “2. No”. Other questions are of “multiple options” and “Rank cases”. There were a total of 25 questions, which were compiled according to the Omani ethical regulations and COVID-19 related information.

1.1 Location

The study was conducted in all the eleven governorates of Oman namely, Muscat, Dhofar, Musandam, Al Buraimi, Ad Dakhliya, N. Batinah, S. Batinah, S. Sharqiyah, N. Sharqiyah, Adh Dhahira and Al Wusta. The questionnaire was sent randomly to all the above-mentioned governorates through a link with the strategy previously described. The selected regions were provisioned to give a different picture of vaccine acceptance since they have different characteristics demographically and specifically to immunization. The geographical, as well as population diversity in the selected governorates, aimed to positively inform and impact the richness of the study results while providing a portrait of vaccine hesitancy and acceptance in Oman. (Fig. 6)

1.2 Study population and inclusion criteria

The study was conducted on a convenience sample of both Omani and non-Omani residents from elders and adults groups, both male and female which were randomly selected. The inclusion criteria are:

- Both Omani and non- Omani residents residing in any of the 11 governorates of Oman
- 20 years or older at the time of participation in the study

1.3 Sample size calculation

The sample size calculation is carried with the following formula

$$\text{Sample size} = \frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p\,(1-p)}{e^2 N}\right)}$$

- Where, z= z-score, let us assume that the desired confidence interval for our study is 95% so the z-score is 1.96
- N= population size
- e= margin of error, assuming a margin of error to be 0.05
- p= approximation of proportion of public and healthcare workers hesitant to get vaccinated.

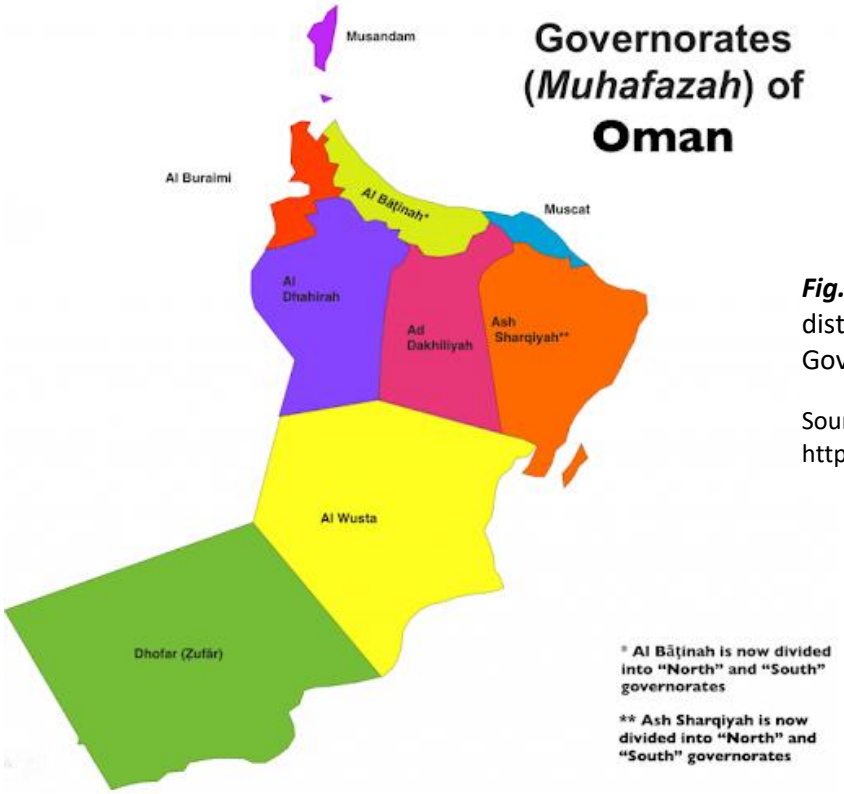

Fig. 6: Geographical distribution of the Governorates of Oman.

Source: Oman travels http://www.omnia-travel.com/

Tab. 3 Estimated sample size for each governorate to be included in the study population.

No.	Governorates	Population aged 20 years or above (General public)	The sample size for the General public
1	Muscat	1185990	385
2	Dhofar	355881	384
3	Musandam	33189	380
4	Al Buraimi	88872	383
5	Ad Dakhliya	306451	384
6	N. Batinah	542082	384
7	S. Batinah	286328	384
8	S. Sharqiyah	215529	384
9	N. Sarqiyah	192490	384
10	Adh Dhahira	150295	384
11	Al Wusta	36565	381

Note: These are the estimated sample sizes for each governorate for the study group. The total number of responses for each governorate may vary depending on the response rate and the timeline for data collection.

2 Ethical Considerations

2.1 Study Approval

The study was conducted following the ethical guidelines from the Ministry of Health, Oman, and ethical approval was obtained from the concerned authority (Ethical Review Board, MOH, Oman) before the onset of the study. (Reference number: MoH/CSR/20/24135)

2.2 Informed Consent for the study:

Participation in the study was completely voluntarily. All the study participants were asked to declare the consent before answering the survey. The informed consent was attached to the questionnaire itself. All participants were explained that their participation in the study was completely voluntary and that they were free to not take part in the research if they did not wish to do so and choosing not to participate would not affect them in any aspect. They were informed that they could stop participating in the study at any time without their daily activities being affected.

3 Study procedure

The study was conducted by the Network for Education and Support in Immunization (NESI), University of Antwerp, Belgium in collaboration with the Office of Health Affairs, Ministry of Health, Oman. The date of data collection was from 22nd to 25th of December 2020. The data collection was conducted by sending the questionnaire links to the target population in all the governorates. In addition, the online questionnaire was adjusted in such a way that only one response can be sent through one link in order to avoid duplication of the data. When the responses were collected in SurveyMonkey, the data was subsequently analysed. There was a total of 966 responses representing a 62% completion rate.

4 Data Analysis

The data was analysed using IBM® SPSS® Statistics Version 27.0. Frequencies and percentages were used to describe the socio-demographic characteristics. Besides that, the mean, standard deviation, and skewness of socio-demographic variables were calculated when possible. A chi-square test was used to assess the difference between subgroups and an analysis was conducted separately categorised by age, gender, marital status, educational level, employment status and geographical location (governorates) to test the association between the variables. $p < 0.05$ (two-tailed test) will be considered statistically significant. Phi and Cramer's value was used to assess the degree of association. Fisher's exact test was performed when less than 5 of the expected count presented in 1 degree of freedom(df) table. Multiple logistic regressions were used to assess the factors associated with vaccine acceptance and barriers to vaccination. A binary logistic regression analysis was performed to evaluate predictors of willingness to accept vaccination against COVID-19 and attitudes towards COVID-19 vaccination. Variables with a p-value < 0.2 in the bivariate analysis were further entered into a multivariate logistic regression model where the adjusted odds ratio (AOR) and their corresponding 95% confidence interval were calculated to explore the association related to risk perception, perceived facilitators and barriers towards COVID-19 vaccination and trust on government. Friedman's test was used to calculate the mean ranking for priority population for COVID-19 vaccination, information sources and trust on information sources related to COVID-19 and COVID-19 vaccine.

Chapter 3

Results:

1 Socio-demographic factors

There was a total of 966 responses representing a 62% complete response rate. The 966 participants were from 10 governorates of Oman (No participation of Al Wusta) with a majority coming from the capital, Muscat (n= 318; 32.9%). There were 612 (63.4%) female and 354 (36.6%) male participants, all 20 years old or above. Most of the participants were between 30-39 (n=413; 42.8%) while groups of 40-49 (n= 328; 34%) and 20-29 (n= 159; 16.5%) were also representative. Nevertheless, there was a lower participation of older age groups 50-59 (n=58; 6%) and >60 (n=8; 0.8%). Most participants were Omani (n = 918; 95%) with only 48 (5%) non-Omani. A greater number of participants were married (n= 793; 82.1%) and 173 (17.9%) single. The majority were pursuing higher education (n=769; 79.6%) in contrast with only 4 (0.4%) with non-formal education. Additionally, 7 (0.7%) participants had preparatory level education or less and 186 (19.3%) completed secondary education. As for employment, 695 (71.9%) were employed and 271 (28.1%) were jobless. In addition to that, 610 (74.1%) had a governmental job position whereas 213 (25.9%) had a job that is not associated with the government (Table 4).

1.2 Socio-demographic factors in association with willingness to get COVID-19 vaccinated

Out of 966 participants, 265 (27%) were willing to get vaccinated (vaccine acceptors), 365 (38%) were not sure and 336 (35%) were unwilling to get vaccinated. The last 2 mentioned categories (No and not sure) were later categorized as vaccine hesitators (n=701; 72.6%). After that, these categories were compared with the socio-demographic factors. (Fig. 7)

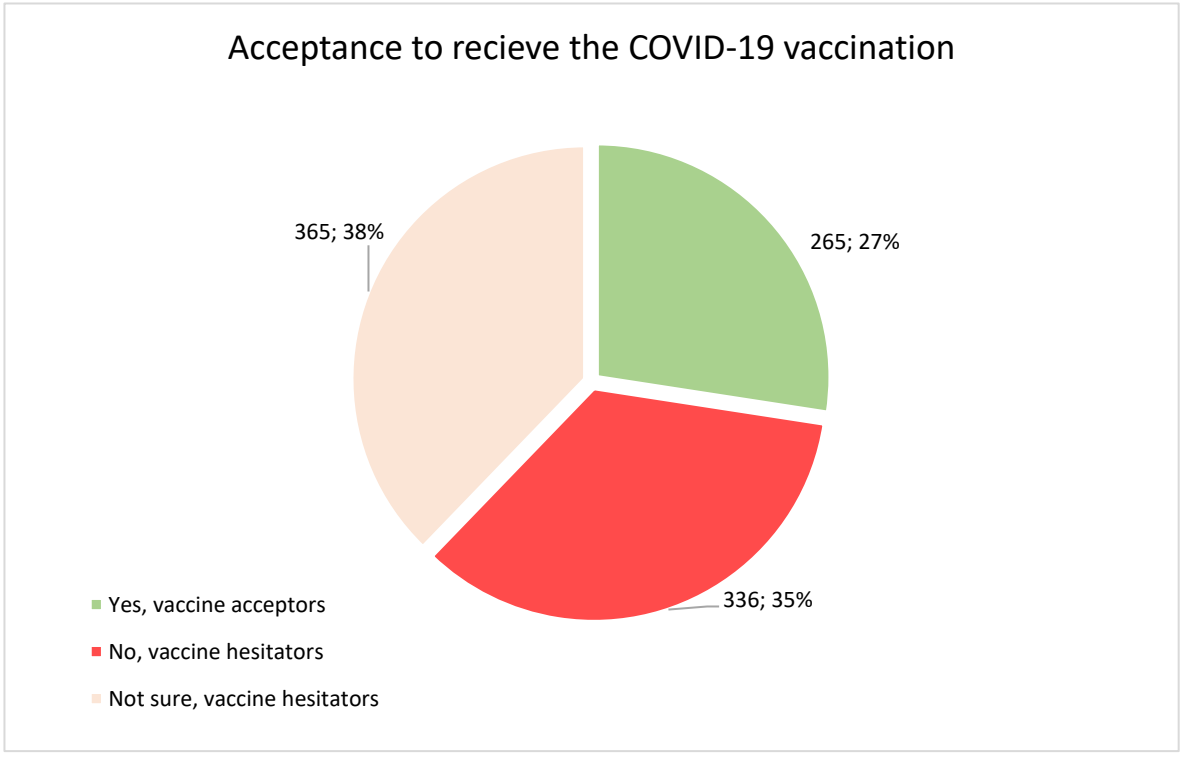

Fig 7: Graphical representation of participants who are COVID-19 vaccine acceptors vs hesitators in Oman.

1.1.1 Governorate vs willingness to get COVID-19 vaccinated

Regarding the governorate where the participants were living in comparison with their willingness to get vaccinated, the study found higher levels of hesitators in Dhofar (80%), South Al-Sharqiyah (79.2%) and North Al-Batinah (76.3%) with the other governorates following close in number. It is important to mention that Musandam (n=3; 60%) Al-Buraymi (n=4; 50%) and Al-Dhahirah (n=47; 36.7%) were the governorates with the highest amount of vaccine acceptors. A cross-tabulation between the governorate and willingness to get vaccinated showed no significant association between these variables (p=0.135, Pearson Chi-squared). Additionally, a binary linear regression was performed to analyse the willingness to get vaccinated in different governorates, using Muscat as the reference variable. The model had a good fit (p=1.000 Hosmer and Lemeshow Test) and participants from North Al-Batinah, South Al-Batinah and North Al-Sharqiyah showed a statistically significant association with the willingness to get vaccinated. However, the association was negative ($\chi2$= 4.20; p=0.040; OR [95% CI]: 0.58[0.34-0.98]); ($\chi2$= 4.77; p=0.029; OR[95% CI] 0.53; [0.31-0.94]); ($\chi2$=4.27; p= 0.039; OR[95% CI]:0.45; [0.21-0.96]. Therefore, these governorates were less willing to get the COVID-19 vaccine when compared with Muscat, the capital city of Oman. (Table 4)

1.1.2 Age vs willingness to get COVID-19 vaccinated

With regards to age, the highest percentage of COVID-19 vaccine acceptors were in the age range of >60 (n= 3; 37.5%) although the sample size is small, which represents a challenge for a concrete conclusion. In contrast, more vaccine hesitators were found in the age range of 30-39 (n=312; 75.5%) followed by 40-49 (n=238; 72.6%). There was no significant association between age and willingness to get vaccinated as showed in a cross-tabulation test (p= 0.135 Pearson Chi-squared). The Binary linear regression had a good fit (p=1.000 Hosmer and Lemeshow Test) and the results showed a negative significant association between the age rank 30-39 and willingness to get vaccinated ($\chi2$= 4.56; p= 0.033; OR[95% CI]:0.65; [0.43-0.96]). This means that the age group 30-39 was less likely to get vaccinated when compared to the youngest group (20-29). On the other hand, the elderly group (>60) has no statistically significant association to accept the COVID-19 vaccine when compared to other age groups ($\chi2$= 0.06; p= 0.808; OR[95% CI]:1.20; [0.28-5.21]). (Table 4)

1.1.3 Gender vs willingness to get COVID-19 vaccinated

It was seen that 147 (41.5%) males were willing to get COVID-19 vaccinated in contrast to 207 (58.5%) males who were hesitant to get the vaccine. As for females, there were 118 (19.3%) participants willing to get vaccinated in contrast to 494 (80.7%) that were hesitators. The results of the cross-tabulation test between willingness to get vaccinated and gender showed a significant association (Pearson chi-square <0.001 and phi and Cramer´s value: 0.240) whereas the binary regression analysis showed a model with good fit (p=0.001; Omnibus Test) and a significant association between gender and willingness to be vaccinated ($\chi2$=53.64; p=0.001; OR[95% CI]:2.97; [2.22-3.98]), meaning that males are almost three times more likely to get vaccinated compared to females. (Table 4)

1.1.4 Marital status vs willingness to get COVID-19 vaccinated

As for marital status, there was a difference between vaccine acceptors who were single (n=55; 31.8%) and hesitators (n=118; 68.2%) in comparison to married vaccine acceptors (n=210; 26.5%) and married hesitators (n=583; 73.5%). Nevertheless, there was no statistical association between these variables (p=0.156 Pearson Chi-squared) which indicates that uptake of COVID 19 vaccination is independent of marital status. (Table 4).

Tab. 4 Binary logistic regression and cross-tabulation test on socio-demographic characteristics vs willingness to get COVID-19 vaccinated.

Socio-demographic characteristics:	**Frequency**		**Vac. Acceptors**		**Vac Hesitators**		**Crosstabs**		**Willingness to get vaccinated**			
	n= 966		**n= 265; 27.4%**		**n= 701; 72.6%**		**Chi-squared**		**Yes, vs no and not sure.**			
	n	*%*	*n*	*%*	*n*	*%*	χ2	*p*	*p*	*OR*	*[95% CI]*	
Governorate												
®Muscat	318	32.9	88	27.7	230	72.3				Ref		
Dhofar	25	2.6	5	20	20	80			0.061	0.66	0.43	1.02
Musandam	5	0.5	3	60	2	40			0.114	0.43	0.15	1.22
Al-Buraymi	8	0.8	4	50	4	50			0.308	2.58	0.42	16.03
Al-Dakhiliyah	143	14.8	36	25.2	107	74.8			0.456	1.72	0.41	7.21
North Al-Batinah	114	11.8	27	23.7	87	76.3			**0.040***	**0.58**	**0.34**	**0.98**
South Al-Batinah	69	7.1	17	24.6	52	75.4			**0.029***	**0.53**	**0.30**	**0.94**
South Al-Sharqiyah	53	5.5	11	20.8	42	79.2			0.086	0.56	0.29	1.08
North Al-Sharqiyah	103	10.7	27	26.2	76	73.8			**0.039***	**0.45**	**0.21**	**0.96**
Al-Dhahirah	128	13.3	47	36.7	81	63.3	13.6	0.135	0.090	0.61	0.35	1.08
Age												
®20-29	159	16.5	53	33.3	106	66.7				Ref		
30-39	413	42.8	101	24.5	312	75.5			**0.033***	**0.65**	**0.43**	**0.96**
40-49	328	34	90	27.4	238	72.6			0.181	0.76	0.50	1.13
50-59	58	6	18	31	40	69			0.749	0.90	0.47	1.72
≥ 60	8	0.8	3	37.5	5	62.5	5.4	0.248	0.808	1.20	0.28	5.21
Gender												
Male	354	36.6	147	41.5	207	58.5			**0.001****	**2.97**	**2.22**	**3.98**
®Female	612	63.4	118	19.3	494	80.7	55.4	**0.001****		Ref		
Marital Status												
Single	173	17.9	55	31.8	118	68.2	2.01	0.156	0.157	1.29	0.90	1.85
®Married	793	82.1	210	26.5	583	73.5				Ref		
Nationality												
Omani	918	95	244	26.6	674	73.4			**0.011***	**0.46**	**0.26**	**0.84**
®Non-Omani	48	5	21	47.8	27	56.3	6.75	**0.009***		Ref		
Education												
Non formal education	4	0.4	1	25	3	75			0.869	0.87	0.09	7.99
Preparatory or less	7	0.7	3	42.9	4	57.1			0.419	1.86	0.41	8.38
Secondary	186	19.3	40	21.5	146	78.5			**0.048***	**0.68**	**0.46**	**0.99**
®Diploma or higher	769	79.6	221	28.7	701	72.6	4.7	0.181		Ref		
Current employed												
Yes	695	71.9	201	28.9	494	71.1			0.097	1.32	0.95	1.82
®No	271	28.1	64	26.6	207	76.4	2.75	0.097		Ref		
Occupation sector												
Governmental	610	74.1	164	26.9	446	73.1			0.202	0.80	0.57	1.13
®Non-Governmental	213	25.9	67	31.5	146	68.5	1.63	0.201		Ref		

OR[95% CI]:Odds ratio; *p:* p-value; CI: Confidence interval; ®: reference group; *: Statistically significant as $p \leq 0.05$; **: statistically highly significant as $P < 0.001$; Acceptors= yes; Hesitators= no and not sure.

1.1.5 Nationality vs willingness to get COVID-19 vaccinated

Non-Omani participants (n=21; 47.8%) were more willing to get the COVID-19 vaccine than Omanis (n=244; 26.6%). A crosstab test (*p*=<0.001 Pearson chi-squared) showed an association between nationality and willingness to get vaccinated. To complement, a binary logistic regression showed a good fit (*p*=0.013 Omnibus coefficient) and a negative association between an Omani nationality with a willingness to get vaccinated (*p*= 0.011; OR[95% CI]:0.46 [0.26-0.84], which indicated that Omanis were less likely to get the COVID-19 vaccine when compared to non-Omanis (Table 4)

1.1.6 Education vs willingness to get COVID-19 vaccinated

Regarding education level, the highest percentage of COVID-19 vaccine hesitators had completed a secondary diploma (n=146; 78.5%) or higher education (n=701; 72.6%). With regards to acceptors, participants who had preparatory or less education had the highest percentage of willingness to get vaccinated (n=3; 42.9%). A crosstab test showed no statistical association (*p*= 0.181 Likelihood ratio). The linear regression analysis showed a significant association between secondary educational level and willingness to get vaccinated (χ2=3.91; *p*= 0.048; OR[95% CI]:0.68 [0.46-0.99]) In conclusion, participants with a secondary education were less likely to get vaccinated in comparison to the reference group (Diploma or higher education) (Table 4)

1.1.7 Employment and occupation sector vs willingness to get COVID-19 vaccinated

About the active employment and occupation sector, there was no significant variability among the percentage of acceptors and hesitators between groups nor a statistically significant association in the crosstabs test and binary logistic regression test. (Table 4)

2 COVID-19 awareness and perceived risk

Out of 966 participants, the majority (n=946; 97.9%) stated being aware of the COVID-19 cases in Oman. There were 831 (86%) respondents who knew about the international COVID-19 vaccine development and 945 (97.8%) knew about the introduction of the COVID-19 vaccine in the country. This illustrates the high level of knowledge of the current pandemic crisis and possible therapeutics in the country and globally. Furthermore, 911 (94.3%) participants knew someone who had been sick with COVID-19, 777 (80.4%) believed of being at risk of contracting COVID-19 and 157 (16.3%) had already been infected with COVID-19. Likewise, 704 (72.9%) participants felt that COVID-19 affected their life personally, socially mentally or economically. In contrast, only 16.3% (n=157) knew someone who was ill with the COVID-19 disease at the moment of the interview. (Table 5. Fig.8). Regarding the main worries about the COVID-19 pandemic, there were 761 (82.6%) participants who reported that infecting someone was the main reason to be worried. Additionally, an economic crisis (n=723; 78.7%), getting infected by others (n=563; 62.9%) and death (n=505; 55.9%) were other worries among the participants. On the other hand, losing their job did not seem to be the main worry for most participants (n=607; 70.8%) (Table 5, Fig 9).

2.1 Willingness to get vaccinated in association with COVID-19 awareness and perceived risks

2.1.1 Awareness of the COVID-19 Cases in Oman vs willingness to get COVID-19 vaccinated

Regarding the awareness of COVID-19 cases in Oman, there were 260 (27.5%) participants who were aware of the cases and were willing to accept the COVID-19 vaccine but 636 (72%) would not accept the vaccine even though they knew of the cases in Oman. The cross-tabulation test (*p*=0.805 Pearson chi-squared) and the binary logistic regression showed no statistical significance. Therefore, the uptake of COVID 19 vaccination is independent of awareness of COVID-19 cases in Oman.

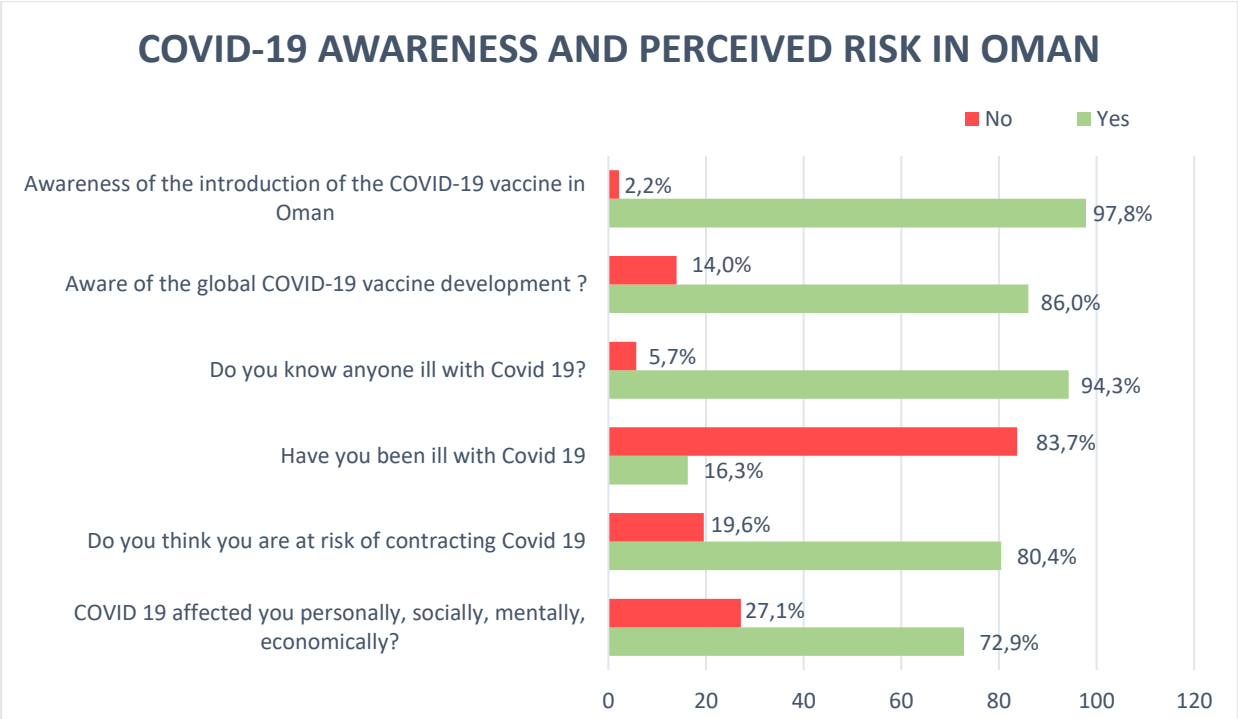

Fig. 8 Graphical representation of awareness and perceived risks of COVID-19 pandemic among participants in Oman. Response rate of 100% n=966.

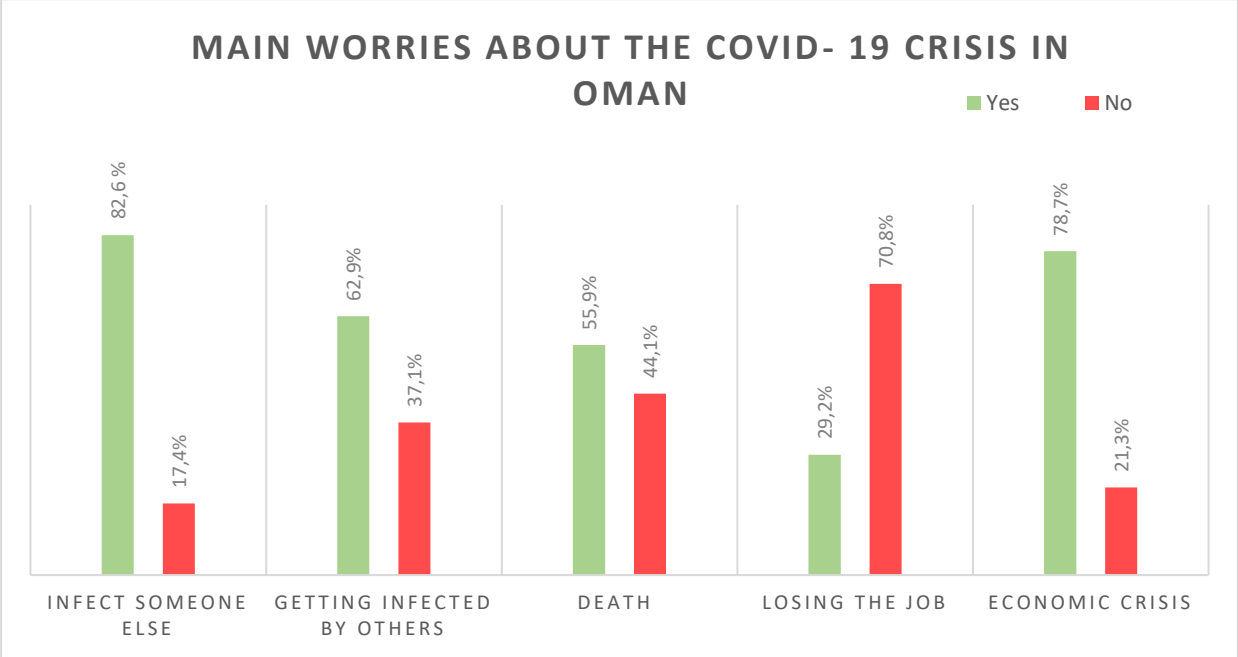

Fig. 9 Graphical representation of the proportion of main worries about the COVID-19 pandemic crisis in Oman.

*Response rate was lower than 100% and can variate among the responses.

2.1.2 COVID-19 pandemic main worries vs willingness to get COVID-19 vaccinated

It was found that 225 (29.6%) participants who pointed out "infecting someone else" as their main worry would accept the COVID-19 vaccine, whereas 536 (70.4%) would not accept the vaccine. A crosstab test showed a significant association between the willingness to get vaccinated and fear to infect someone else (0.022 Pearson Chi-squared) with a weak effect on the dependent variable (0.07 Phi-Cramer´s V). Additionally, a binary logistic regression analysis revealed a positive association between infecting someone else and the willingness to get vaccinated ($\chi2$=5.17; *p*=0.023; OR[95% CI]:1.62 [1.07-2.44]; 0.019 Omnibus test) meaning that participants who were worried to infect someone else were 1.6 times more likely to get vaccinated when compared with the ones who did not worry. In addition, 30.9% (n=174) of the participants who were worried about "getting infected by others" would accept the COVID-19 vaccine but 69.1% (n=389) would not receive the vaccine. There was a significant association between getting infected by others and the willingness to get COVID-19 vaccinated (*p*= 0.013 Pearson Chi-squared) and a positive predictive relationship between variables ($\chi2$= 6.12; sig=0.013; OR[95% CI]:1.48 [1.08-2.02] omnibus: 0.012). Thus, participants were 1.4 times more likely to accept the COVID-19 vaccine when they were worried about getting infected with COVID-19 by others.

Furthermore, 154 (30.5%) participants who were worried about dying from COVID-19 infection were willing to get the COVID-19 vaccine whereas 351 (69.5%) would not get vaccinated. On the other hand, 97 (24.3%) participants who were not worried about dying by COVID-19 infection would get vaccinated but 302 (75.7%) would not get the vaccine. The cross-tabulation test revealed a significant association between variables (*p*=0.039 Pearson Chi-squared) and the binary logistic regression showed a positive predictive relationship between the dependent and independent variable ($\chi2$= 4.24; *p*=0.40; OR[95% CI]:1.37; [1.01-1.84]; Omnibus: 0.039) Therefore, it is more likely for participants who consider dying as the main worry to get the COVID-19 vaccination.

With regards to the loss of a job, 75 (30%) participants who were worried about getting jobless would get the COVID-19 vaccine but 175 (70%) were hesitant about getting vaccinated. There was no significant association between these variables. (Table 5) Finally, from the participants that considered an economic crisis as their main worry, 202 (27.9%) were willing to get vaccinated in contrast to 571 (72.1%) who are not willing to get the COVID-19 vaccine. A crosstab test and binary logistic regression showed no statistically significant association between these variables (Table 5).

2.1.3 COVID-19 personally, socially, mentally, or economically effect vs willingness to get COVID-19 vaccinated

Results showed that 201 (28%) of COVID-19 vaccine acceptors and 201 (28.6%) hesitators had been affected personally, socially, mentally, or economically by COVID-19. In contrast, 64 (24.4%) vaccine acceptors and 198 (75.6%) hesitators felt that they had not been affected personally, socially, mentally, and economically by the pandemic. There was no significant association between these variables (Table 5).

2.1.4 Perceived risk of contracting COVID-19 vs willingness to get vaccinated.

There were 226 (29.1%) participants that felt at risk of contracting COVID-19 and would accept the vaccine but 551 (70.9%) would not get the vaccine even though they felt at risk. There was a significant association between these variables (*p*=0.020 Pearson Chi-squared) and positive predictive association ($\chi2$= 5.4; *p*=0.020; OR[95% CI]:1.59 [1.07-2.32]. Thus, it is 1.5 times more likely that a participant who believed to be at risk of contracting COVID-19 would get vaccinated than one who did not have this worry. (Table 5).

Tab. 5 Binary logistic regression and cross-tabulation test of awareness and perceived risk about COVID-19 and the willingness to get COVID-19 vaccinated.

COVID-19 awareness and perceived risk	**Frequency n= 966**		**Vac. Acceptors n= 265; 27.4%**		**Vac Hesitators n= 701; 72.6%**		**Crosstabs Chi-squared**		**Willingness to get vaccinated Yes, vs no and not sure.**			
	n	*%*	*n*	*%*	*n*	*%*	χ2	*p*	*p*	*OR*	*[95% CI]*	
Awareness of the COVID-19 Cases in Oman												
Yes	946	97.2	260	27.5	686	72.5			0.805	1.137	0.409	3.160
®No	20	2.1	5	25	15	75	0.061	0.805		Ref		
Has COVID-19 affected your life personally, socially, mentally, or economically?												
Yes	704	72.9	201	28.6	503	71.4			0.202	0.809	0.584	1.120
®No	262	27.1	64	24.4	198	75.6	1.6	0.202		Ref		
Do you think you are at risk of contracting COVID-19?												
Yes	777	80.4	226	29.1	551	70.9			**0.020**	1.578	1.074	2.318
®No	189	19.6	39	20.6	150	79.4	5.4	0.020*		Ref		
Have you been ill with COVID-19?												
Yes	157	16.3	43	27.4	114	72.6			0.989	1.003	0.683	1.471
®No	809	83.7	222	27.4	587	72.6	<0.001	0.989		Ref		
Do you know anyone close to you who was/is ill with COVID-19?												
Yes	911	94.3	253	27.8	658	72.2			0.338	0.726	0.377	1.399
®No	55	5.7	12	21.8	43	78.2	0.924	0.337		Ref		
Awareness of the COVID-19 development in different parts of the world?												
Yes	831	86.0	253	30.4	578	69.6			0.003**	0.645	0.485	0.857
®No	135	14.0	12	8.9	123	91.1	27.1	0.001**		Ref		
Awareness of the COVID-19 vaccine implementation in Oman is once available.												
Yes	945	97.8	264	27.9	681	72.1			0.001**	0.223	0.121	0.411
®No	21	2.2	1	4.8	20	95.2	5.5	0.019*		Ref		
Main worries about COVID-19												
Infect someone else												
Yes	761	82.6	225	29.6	536	70.4			0.023*	1.616	1.068	2.443
®No	160	17.4	33	20.6	127	79.4	5.24	0.022*		Ref		
Getting infected by others												
Yes	563	62.9	174	30.9	389	69.1			0.013*	1.481	1.085	2.022
® No	332	37.1	77	23.2	255	76.8	6.15	0.013*		Ref		
Death												
Yes	505	55.9	154	30.5	351	69.5			0.040*	1.366	1.015	1.838
®No	399	44.1	97	24.3	302	75.7	4.25	0.039*		Ref		
Losing the job												
Yes	250	29.2	75	30	175	70			0.376	1.158	0.837	1.601
® No	607	70.8	164	27	433	73	0.79	0.376		Ref		
Economic crisis												
Yes	723	78.7	202	27.9	521	72.1			0.499	0.883	0.616	1.266
® No	196	21.3	50	25.5	667	74.5	0.45	0.499		Ref		

OR[95% CI]: Odds ratio; *p:* p-value; CI: Confidence interval; ®: reference group; *: Statistically significant as $p \leq 0.05$; **: statistically highly significant as $P < 0.001$; Acceptors = yes; Hesitators= no and not sure.

2.1.5 *Have you been ill with COVID-19? vs willingness to get COVID-19 vaccinated.*

Out of 966 participants, 43 (27.4%) participants had been ill with COVID-19 and would like to get the vaccine whereas 114 (72.6%) that had COVID-19 infection were not willing to get vaccinated. On the other hand, from the participants that had not been ill with COVID-19, 222 (27.4%) would get vaccinated but 587 (72.6%) are hesitant to get vaccinated. There was no significant association between these variables (Table 5).

2.1.6 *Do you know anyone who had COVID-19 vs willingness to get COVID-19 vaccinated.*

There were 253 (27.8%) participants that knew someone who was sick with COVID-19. Therefore, they were willing to get vaccinated but 658 (72.2%) are not willing to get vaccinated even though they knew someone who got previously ill with COVID-19. A cross-tabulation and binary logistic regression test showed no significant association between these variables (Table 5).

2.1.7 Awareness of the COVID-19 global development vs willingness to get COVID-19 vaccinated.

From the participants who were globally aware of COVID-19, 253 (30.4%) were willing to get vaccinated but 578 (69.6%) were not willing to accept the vaccine. There was a significant association (0.019 Pearson Chi-squared) and positive predictive relationship between these variables ($\chi 2=23.2$; $p=$ <0.001; OR[95% CI]:4.49 [2.44-8.26]; Omnibus: $p=$ <0.001;). Therefore, participants who knew about the COVID-19 pandemic and the impact of COVID-19 were 4.4 times more likely to get vaccinated when compared to those who did not know about it.

2.1.8 *Awareness of the COVID-19 vaccine implementation in Oman vs willingness to get vaccinated.*

From the participants who are aware of the COVID-19 vaccine implementation in Oman, 264 (27.9%) were vaccine acceptors but 681 (72.1%) were hesitators. There was a negative significant association (p=0.019 Chi-squared) and a positive predictive relationship between variables ($\chi 2=3.9$; p=0.046; OR[95% CI]:7.75 [1.03-58.06]; Omnibus 0.006). Therefore, it is 7.7 times more likely that someone who knew about the COVID-19 vaccine implementation in Oman would get the vaccine compared to the ones who did not know about it.

3 COVID-19 vaccine confidence and compliance.

From the participants who were willing to get vaccinated (n=265), 70% would accept the vaccine to protect themselves and the people around them; 53.6% believed that the COVID-19 vaccine is effective to prevent future infections, 36.9% stated that COVID-19 is dangerous for their health and only 36.3% believed that the COVID-19 vaccine is safe. On the other hand, 72% of vaccine hesitators mentioned the COVID-19 vaccines' side effects as the main reason for not get vaccinated. Besides, 55% of participants stated that the COVID-19 vaccine is not safe; 26,5% believed the COVID-19 vaccine is not effective and 15.3% thinks that COVID-19 is not dangerous for their health (Figure 10).

3.1 Influenza vaccine acceptors vs willingness to get the COVID-19 vaccine

To evaluate if there was an association between participants who got the Influenza vaccine during the last 5 years and the willingness to get the COVID-19 vaccine, a cross-tabulation test revealed that 55.8% (n=148) of participants who had the Influenza vaccine are willing to accept the COVID-19 vaccine, whereas 44.2% (117) of the participants that did not get the Influenza vaccine during the last 5 years would get the COVID-19 vaccine. There was a positive significant association between the variables ($\chi 2= 9.18$; p=0.003; OR[95% CI]: 1.55 [1.17- 2.06] Omnibus: 0.002), meaning that people who received the Influenza vaccine during the last 5 years were 1.55 more likely to get the COVID-19 vaccine when compared with the ones who did not have the influenza vaccine during the last 5 years.

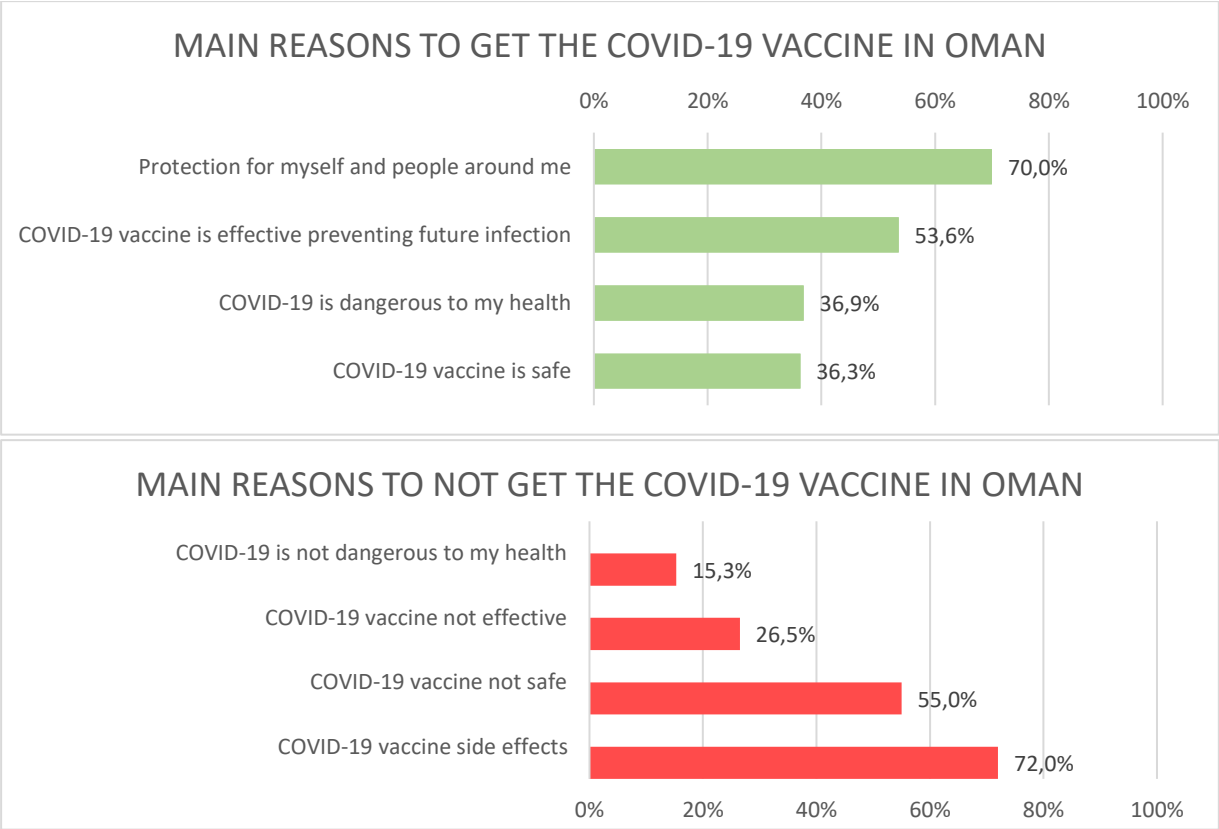

Fig.10 Main reasons to receive or deny the COVID-19 vaccination in Oman.

3.2 Eagerness to receive more information on the COVID-19 vaccine and willingness to get vaccinated.

From the participants that were eager to receive more information about the COVID-19 vaccine (n=531, 87,9%) there were 178 (33.5%) who are willing to get the COVID-19 vaccine and 353 (66.5%) who are not willing to get vaccinated. A crosstab analysis revealed a significant association between variables (p=0.001) and a binary logistic regression showed a positive predictive association (χ2=10,74; p=0.001; OR[95% CI]:3.177 [0.158-0.628] Omnibus: <0.001). Therefore, people who were open to receive more information were 3.1 times more likely to get the COVID-19 vaccine than the ones who were not eager to get more information.

3.3 Potential barriers for the COVID-19 vaccination in Oman

To develop a successful vaccine implementation plan, it is essential to have a deep understanding of potential barriers and public opinion regarding the COVID-19 vaccine. Therefore, levels of agreement on various potential barriers were evaluated and represented graphically in figure 11. A great majority of participants strongly agreed (n=235; 39.2%) or agreed (n=257; 42.8%) that they knew the importance of vaccination before the COVID-19 pandemic. Regarding the recognized value of vaccination after the COVID-19 pandemic, the majority agreed (n=242; 40.3%) or strongly agreed (n=185% 30.8%) to recognize that vaccines are important. Additionally, it was found that most of the participants trust the government on COVID-19 vaccination planning and introduction in Oman (agree= 253; 42.1% and strongly agree=178; 29.6%); that the government is transparent with the information they provide regarding the COVID-19 pandemic (agree= 272; 45.3% and strongly agree=179; 29.8%); plus, they believe that the COVID-19 crisis was well handled by the government of Oman (agree= 293; 48.8% and strongly agree= 177; 29.5 %). Regarding the safety and effectiveness

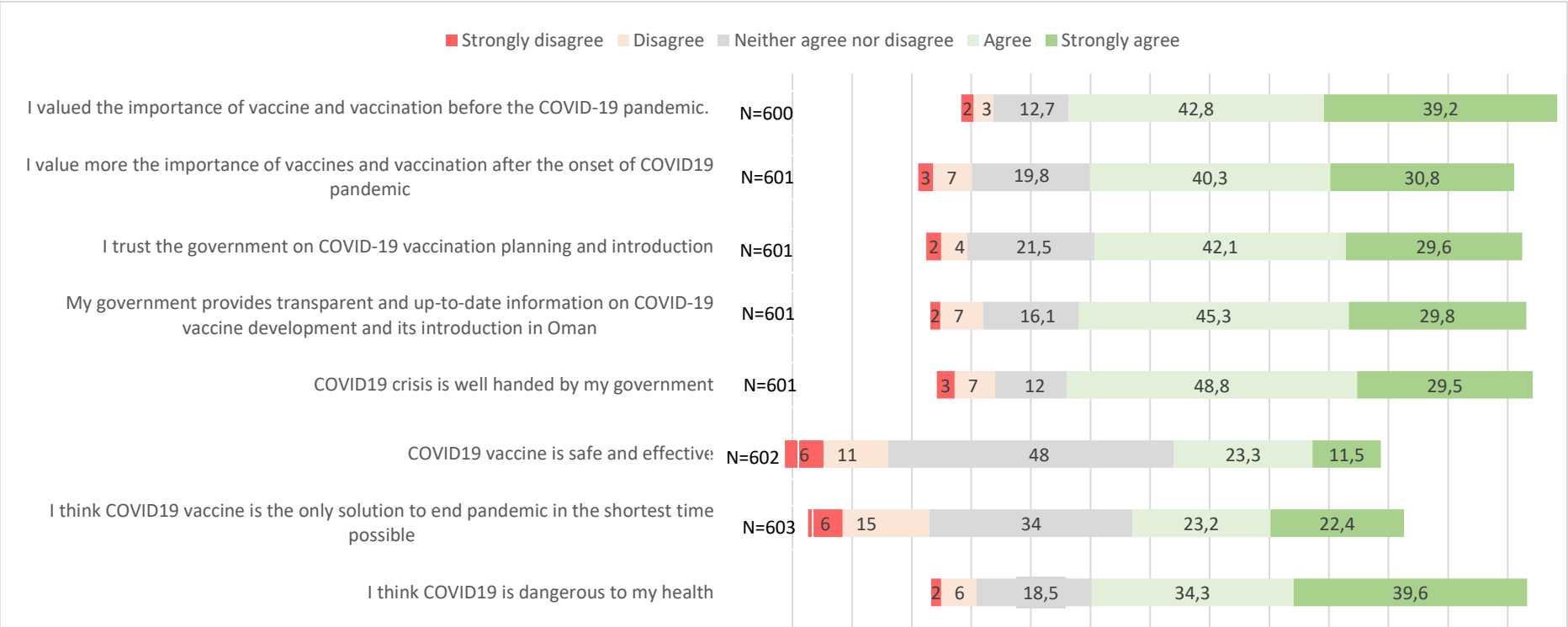

Fig. 11 Level of agreement on the following statements, represented by percentages.

Note: Neither agree nor disagree was used as the reference group.

of COVID-19 vaccines, most participants had a neutral opinion (neither agree nor disagree= 289; 48%). In the same way, 34% (n= 205) of participants had a neutral opinion about vaccination being the only solution to end the pandemic. As for the perceived danger of COVID-19 infection, the majority strongly agree (n=239; 39.6%) that COVID-19 is dangerous for their health. Based on the results it is possible to conclude that, even though most participants understood the danger of COVID-19 infection, know about the importance of vaccination, and trust the government to manage the crisis in the country, most participants are hesitant about the safety and efficacy of the COVID-19 vaccine. (Figure 11)

3.4 Willingness to get COVID-19 vaccinated vs potential barriers for the COVID-19 vaccination in Oman, multinominal logistic regression analysis.

For convenience purposes, the levels of agreement were reorganized into new categories: positive (strongly agree and agree), neutral (neither agree nor disagree) and negative (disagree, strongly disagree). The Binary logistic regression results showed that most of the statements involved as potential barriers had a statistically significant association with willingness to get vaccinated. However, it was not the case for multinominal logistic regression analysis. Thus, people who agreed with the statements "COVID-19 vaccine is safe and effective" (46.09 [5.65- 376.16]*) and "I think COVID-19 vaccine is the only solution to end pandemic in the shortest time possible" (6.18 [1.62- 23.55]*) had a significant association with willingness to get vaccinated, being 46 and 6 times more likely to accept the COVID-19 vaccine when compared with their counterparts. (Table 6)

Tab. 6 Multinominal logistic regression and Binary logistic regression test of willingness to get vaccinated vs potential barriers for the COVID-19 vaccination in Oman.

Potential barriers for the COVID-19 vaccination in Oman	**Frequency**	**Binary Logistic regression**		**Multinominal logistic regression**	
	N= 966	Willingness to get vaccinated (Yes vs no and not sure)		Willingness to get vaccinated (Yes vs no and not sure)	
	Yes	*B*	uOR [95% CI]	*B*	aOR [95% CI*]*
I valued the importance of vaccine and vaccination before the COVID-19 pandemic	492	----	---------	-----	----------
I value more the importance of vaccines and vaccination after the onset of the COVID-19 pandemic	427	3.62	37.5 [5.1-273.8]**	0.932	2.54 [0.20- 32.84]
I trust the government on COVID-19 vaccination planning and introduction	431	1.81	6.08 [2.13-17.38]**	-0.243	0.78 [0.13- 4.75]
My government provides transparent and up-to-date information on COVID-19 vaccine development and its introduction in Oman	451	1.29	3.65 [1.61-8.27]**	-0.640	0.53 [.13- 2.08]
COVID-19 crisis is well handed by my government	470	0.87	2.34 [1.18-4.84]*	0.103	1.11 [0.34- 3.59]
COVID-19 vaccine is safe and effective	209	5.5	249.9[34.1-1831.6]**	3.83	46.09 [5.65-376.16]*
I think the COVID-19 vaccine is the only solution to end the pandemic in the shortest time possible	275	4.02	55.65 [17.26-179.3]**	1.821	6.18 [1.62-23.55]*
I think COVID-19 is dangerous to my health	446	1.857	6.41 [2.26- 18.18]**	1.123	3.07 [0.77- 12.30]

Data reported is only for positive (strongly agree and agree) with a negative statement as reference category; OR[95% CI]: Odds ratio; CI: Confidence interval; ®: reference group; B: Regression coefficient; *: Statistically significant as $p \leq 0.05$; **: statistically highly significant as $P < 0.001$; Acceptors = yes; Hesitators= no and not sure; the reference category for Multinominal logistic regression is: Hesitator.

4 Preference and credibility of information sources.

The mean and Friedman´s ANOVA test on ranked data were performed to analyse the opinion of the surveyed population with regards to who should get the vaccine once available and the sources of information that people consulted and trusted the most. Concerning the population that should be prioritized for the COVID-19 vaccine once available, most participants think that 1st Health workers, 2nd frontline/ essential workers and 3rd elderly people should be the priority groups for COVID-19 vaccination. Concerning the main sources of information, 1st Medical doctors, 2nd Newspapers/News on the internet and 3rd social media were the most consulted sources for the participants. Finally, the sources of information that the subjects trust the most were 1st Medical Doctors, 2nd Newspapers/News on the internet, 3rd the Ministry of Health of Oman website. This puts in evidence the importance for medical doctors to receive and distribute conscious, understandable, and precise information with regards to the COVID-19 crisis and vaccination. At the same time, it shows the importance of infodemics management for the monitoring and distribution of understandable and impartial information on social media, news, and newspapers regarding COVID-19. (Table 7)

Tab. 7 Friedman ANOVA test for preference and credibility of information sources. (Mean rank categorized in order of importance.)

Preference and credibility of information sources			
The rank of the population that should be prioritized for the COVID-19 vaccine	*Mean*	*Chi-square*	*p=value*
Health workers	2.13	1733.9	<0.001
Frontline and essential workers	2.33		
Elderly people	2.87		
People with underlying medical conditions	3.13		
Young population	5.11		
Children	5.42		
The rank of main sources of information			
Doctors	3.55	900.9	<0.001
Newspaper/News on the internet	3.80		
Other social media (Instagram, Facebook, Twitter)	4.29		
Family and friends	5.10		
Ministry of Health website	5.25		
WhatsApp	5.28		
Radio	5.82		
Television	4.46		
Poster/leaflet/brochure	7.46		
The Rank sources you trust the most for COVID 19 vaccine information.			
Doctors	2.04	1660.3	<0.001
Newspaper / News on the internet	4.00		
Ministry of Health website	4.30		
Television	4.45		
Family and friends	4.80		
Radio	5.11		
Other social media (Instagram, Facebook, Twitter)	6.15		
WhatsApp	6.98		
Poster/leaflet/brochure	7.18		

Chapter 4

Discussion

The novel COVID-19 disease has affected the world impacting all communities and individuals and leading to a dramatic loss of human life worldwide. Vaccines are a key strategy to control and stop the escalation of the COVID-19 pandemic. However, its acceptancy is varied with space, time, social class, ethnicity, and contextual human behaviour [31,33,34,36,38,39) This study aims to understand how the COVID-19 vaccine will be accepted by the general population of Oman. A web-based self-administered questionnaire was used to provide information to develop immunization strategies for the Oman population, especially adults and elders with 966 participants from 10 governorates in the country.

1.1 Factors related to COVID-19 vaccine perception among the general population in Oman.

It was found that 27% (265/966) of the participants would accept the COVID-19 vaccine once available but 38% (365/966) were not sure and 35% (336/966) would not accept the vaccine. Thus, the latter two were classified as vaccine hesitators (701/966; 72.6%). Though there have been limited studies that explore the intention of COVID-19 vaccine uptake in the current crisis, our results showed similar levels of COVID-19 vaccine acceptance when compared with neighbouring countries like Kuwait (23.6%) and Jordan (28.4%) [45]On the contrary, this research showed a significantly low level of vaccine acceptance when compared with studies of the general population of Iran (64.3%)[46]; Saudi Arabia (64.7%)[47] and when compared with studies from Health workers from Pakistan (60%) [48]and the EMR (58.0%) [49]. The low vaccine acceptance in Oman is alarming since it appears to be among the lowest acceptance rates globally. [45]. The levels of vaccine hesitancy can be attributed to the "3 Cs" model, which points to confidence, complacency, and convenience. A lack of confidence in COVID-19 vaccines or providers, complacency towards the need for vaccination, and vaccine inconvenience in terms of inaccessibility are the leading factors behind the COVID vaccine hesitancy in the region. (31,33,34)

In this study, most participants who are willing to get vaccinated (70%) would accept the vaccine to protect themselves and the people around them, 53.6% believe the vaccine could effectively prevent future infections, 36.9% would get vaccinated because they think that COVID-19 is dangerous for their health and 36.3% believe that the COVID-19 vaccine is safe. On the other hand, the vaccine-hesitant group mentioned side-effects (72%) as the main reason to not get the COVID-19 vaccine. In addition, 55% of participants stated that the COVID-19 vaccine is not safe; 26.5% believed that the COVID-19 vaccine is not effective and 15.3% emphasized that COVID-19 is not dangerous for their health (figure 10). Similar results were found in a study done by Rehman et al (2021) regarding COVID-19 vaccine acceptance on health care workers in Pakistan where 326 (75%*)* agreed to feel less worried about getting COVID-19 if vaccinated and 329 (75%*)* acknowledged that vaccination decreases their risk of contracting COVID-19 and its complications. As for hesitators, in Rehman´s study, 174 (40%) indicated that they are worried about possible side effects of COVID-19 vaccination, (67%) were concerned about the efficacy of COVID-19 vaccination whereas 293 (67%) were concerned about the safety. These results put in evidence that there is high concern about COVID-19 vaccine safety, efficacy and side effects. Possible reasons for that include the global and easy access to information related to the pandemic (infodemics). The COVID-19 pandemic is "on the loupe" and information shared by the media does not always show the full picture or does not always appear to be scientifically proven. In addition to that, there are high levels of sensationalism and conspiracy theories especially in social media, as discussed further. This set of factors represent a public health challenge to control the COVID-19 pandemic as fewer people would 'definitely' accept the COVID-19 vaccine that is required for herd immunity, and that misinformation could push these levels further away from herd immunity targets [45,46,47].

In our study, people who received the Influenza vaccine during the last 5 years were 1.55 times more likely to accept the COVID-19 vaccine. These findings are in line with the study conducted by Awaidy, S.T.A. et al. (2020) in Oman where Health Workers reported higher levels of general vaccine acceptance if they have been receiving the influenza vaccination during the last 5 years. Besides, participants who received the influenza vaccine had similar reasons as the COVID-19 vaccine acceptors to get immunized. This includes protection of themselves and their families, high risk of exposure to infection, reduction in illness, among other benefits. [39]

Interestingly, there was a higher participation of middle-aged adult population (30-39= 42.8%; 40-49=34%) and females (63.4%). However, males were 3 times more likely to accept the COVID-19 vaccine (x^2=53.64; p=<0.001; OR: 2.97; [2.22-3.98]) than females. Similar results were found in a study conducted in Iran where men had higher odds than women (aOR=1.32, [1.13-1.54]) to accept the COVID-19 vaccine [46]. A reason for that is that men in the region have jobs that might expose them to more potential infected cases, sort of construction, driving, or public service jobs. Thus, a higher perceived risk of COVID-19 disease can be in males if compare to females as described in the study of Askarian et al 2020. [46] An additional reason, and also controversial, could be a possible tendency for females in the EMR to be more susceptible to belief in conspiracy theories behind COVID-19 vaccines, as shown in the study done by Sallam et al (2021) in countries of the EMR (mean VCBS: 26.3 vs. 24.1 in males; p < 0.001, M-W).

Supplementary findings showed that Omani (p= 0.011; OR: 0.465 [0.258-0.839] are less likely to accept the COVID-19 vaccine when compared to ex-pats, this could be related to potential barriers that ex-pats could be confronted with (language, health insurance, economic issues etc) that make them feel more susceptible and in higher risk to get the COVID-19 disease. [26,27]. (Table 4) Finally, although there were some other differences in the distribution of other socio-demographic characteristics, these had no noteworthy impact on participants' complacency and confidence towards the COVID-19 vaccine. (Table 4)

To develop a successful vaccine implementation plan, it is essential to have a deep understanding of potential barriers and public opinion regarding the COVID-19 vaccine. A great majority strongly agreed (n=235; 39.2%) or agreed (n=257; 42.8%) about the importance of vaccination, even before the COVID-19 pandemic. On the other hand, participants agreed (n=242; 40.3%) or strongly agreed (n=185; 30.8%) that vaccines are important after the pandemic started. Additionally, it was found that most of the surveyed population trusted the government on COVID-19 vaccination planning and introduction to the country (agree= 253; 42.1% and strongly agree=178; 29.6%; 3.65 [1.61-8.27]**) and that the government is transparent with the information they provide regarding the COVID-19 pandemic (agree= 272; 45.3% and strongly agree=179; 29.8%; 6.08 [2.13-17.38]**). In addition to that, they believe that the COVID-19 crisis was well handled by the Omani government (agree= 293; 48.8% and strongly agree= 177; 29.5 %; 3.65 [1.61-8.27]**). These, as well as individual factors, make participants more likely to get COVID-19 vaccinated. (Table 6) The results are in line with a previous study that was conducted in Saudi Arabia where participants who trusted the health system were 3.05 (aOR:3.05; 95% CI: 1.13–4.92) times more likely to accept the vaccination than those who have reported no trust. Also, these results are in line with what was reported by Sallam, M. (2021) in a systematic review of COVID-19 acceptability done globally where lack of trust in governments and the healthcare system led to the endorsement of conspiracy beliefs and vaccine hesitancy. It is important to mention that the binary logistic regression results showed that even though most of the statements involved as potential barriers had a statistically significant association with willingness to get vaccinated. This was not the case for the multinominal logistic regression analysis. However, people who agreed with the statements "COVID-19 vaccine is safe and effective" (46.09 [5.65- 376.16] *) and "I think COVID-19

vaccine is the only solution to end pandemic in the shortest time possible" (6.18 [1.62- 23.55]*) had a significant association with willingness to get vaccinated. (Table 6)

1.2 Factors related to COVID-19 vaccine knowledge and attitude among the general population in Oman.

A great majority of participants (946/966; 97%) stated being aware of the number of COVID-19 cases in Oman, 831/966 (86%) knew about the international COVID-19 vaccine development and 945/966 (97.8%) knew about the introduction of the COVID-19 vaccine in Oman. This puts into evidence the high level of knowledge for most participants regarding the COVID-19 pandemic and vaccination in the country. Additionally, subjects that thought they were at risk of contracting COVID-19 (x^2=5.4; p=0.020; 1.57[1.07-2.31], or that were aware of the progress in the development of the COVID-19 vaccine in a different part of the world (x^2= 27.1; p=0.003; 0.65[0.48-0.86] and/or if they knew the COVID-19 vaccine would be introduced and implemented in Oman (x^2= 5.5; p=0.022; 1.616[0.121-0.411] were more likely to accept the COVID-19 vaccine when compared to their counterparts (Table 5). Some of these characteristics are predictors in explaining the acceptance of the COVID-19 vaccine as shown in the study of Al-Mohaithef et al (2020), where perceived risk factors of acquiring COVID-19 (aOR:2.13; [1.35–3.85]) are found to be important determinants for COVID-19 vaccine acceptance. Finally, it is worth mentioning that most participants knew someone ill with COVID-19 (94.3%), even though they had not been ill themselves (83,7%). Besides, a great majority had been affected personally, socially, mentally, or economically (72.9%). Nevertheless, these factors did not make them more willing to get the COVID-19 vaccine. (Table 5)

Regarding the population that should be prioritized for the COVID-19 vaccine once available, most participants think that 1st healthcare workers, 2nd frontline/ essential workers and 3rd elderly people should be on the top 3 to receive the vaccine. This is related to the vulnerability and higher mortality rates among the elderly population and healthcare workers. ([8,9,18,19,20]) and due to the understanding that if healthcare staff gets sick with COVID-19, they might not be able to provide key services for patients. Plus, they could be potentially contagious to other groups at risk. Given the evidence of ongoing COVID-19 infections among healthcare personnel and the critical role they play in caring for others, continued protection of them at work, at home, and in the community remains a priority (Table 6). [[50]]

As for the COVID-19 pandemic and vaccine, the main sources of information were 1st medical doctors, 2nd newspapers or 3rd news on the internet and social media (Facebook, Twitter, Instagram). Of these, medical doctors, newspapers, and the ministry of health website are the most trusted (Table 7). It is worth mentioning that healthcare workers are key determinants for trust and acceptance regarding vaccination. For instance, previous studies have consistently shown that people follow the vaccination recommendations of their healthcare workers ([46,40]) therefore they must be well educated about the COVID-19 vaccine, so they can make a strong vaccination recommendation to their patients. Besides, there is a significant trust in the Ministry of health which ranked 3/9 (table 7). Similar results were found in Saudi Arabia where the odds of having greater trust in the health system were 3.05 times higher regarding the intention to uptake the COVID-19 vaccine (aOR: 3.05; 95% CI: 1.13–4.92) [[47]] It is important to note that social media fell in position 7/9 of trusted sources even though it is the 3/9 most consulted. (Table 7) The reason for this could be explained by the high rate of use and easy accessibility of these platforms by ordinary citizens. Thus, individuals may be particularly susceptible to believe in vaccine misinformation transmitted via nonmedical interest groups on social media. Besides, although people are aware of possible fake/sensationalist information in social media, which explains the low trust score, they are usually not well trained to identify reliable trustworthy

information from fake/hoax news. A study done by Sallam et al (2021) in Jordan and Kuwait among other Arab countries showed similar results with lower COVID-19 vaccine hesitancy among those who relied on medical doctors, scientists and scientific journals (mean = 23.9, SD = 11.4), as compared to those who relied on TV programs and news releases (mean = 25.7, SD = 10.0) The highest vaccine hesitancy was seen among those who relied on social media platforms (mean = 27.4, SD = 10.2; $p < 0.001$). Besides, the willingness to get a COVID-19 vaccine was the highest among respondents who relied on medical doctors, scientists, and scientific journals (36.1%). The lowest vaccine acceptance was among respondents who relied on social media platforms (22.1%; $p < 0.001$, $\chi 2$ test). [45] Because our results suggest that exposure to prosocial norms transmitted by trusted doctors, family members, and friends, as well as via social and traditional media are all correlated, it is important for public health efforts to harness each of these sources to promote the COVID-19 vaccine acceptance.

Strengths, limitations, and future prospects.

An important aspect of the present study is that it evaluates the KAP of participants in relationship with the willingness to get the COVID-19 vaccine adding important information on COVID-19 vaccine acceptance in the region. Among other strengths of this study are the large sample size, which decreases the influence of existing bias, the representation of 10 out of 11 governorates of Oman and a relatively high response rate (62%) if compared with other studies in the region. On the other hand, there are several limitations. First, it was asked for the participants to report their intention to receive the COVID-19 vaccine if it is available in the future and when the COVID morbidity and mortality rates were lower in the country if compared to the date, 1st May 2021. A considerable number of study participants (38%) reported "Not sure" about their intention to uptake the COVID-19 vaccination. The real intention could be different when the vaccine is available and when the perceived risk is increased. Thus, the results should take into caution as the intent is never completely predictive of actual behaviour especially considering future distribution barriers that are unforeseeable at this point and therefore were not assessed. In addition, the current study used a sample of online social network groups which excludes those who have no access to the internet. Those with an internet presence are typically younger and of a higher socioeconomic status, and future studies should be sure to include older individuals and those with lower economic means since these populations are at higher risk of COVID-19 disease. Finally, further studies should corroborate our findings with public health promotion interventions and targeting various sociodemographic groups like people without access to the web, elders and/or highly impoverished people. These groups should be taken as a priority to increase the COVID-19 vaccine uptake behaviour in the country, and elsewhere.

Chapter 5

Conclusion

Overall, participants' perceived risk and trust in vaccines, government and the health system were found to be significant predictors towards the intention of receiving the COVID-19 vaccine in Oman. Additionally, this study revealed suboptimal acceptance of the COVID-19 vaccine among participants in Oman. A significant level of hesitancy was found of the COVID-19 vaccine due to multiple factors being the most important the low perceived risk of the COVID-19 disease and lack of trust in COVID-19 vaccines due to possible side effects, lack of safety, efficacy, and effectiveness. This represents a challenge in Public Health as it can reverse hard-won progress in building public trust in the COVID-19 vaccination program and control the pandemic. Findings suggest the need to develop tailored strategies to address concerns identified in the study to ensure optimal vaccine acceptance among the general population in Oman.

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a. Is the topic situated well within the broader scientific context?						
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19-20 highest honours +	a. Exceptionally good positioning of the topic within the broader scientific context; the literature is critically interpreted and processed by the student b. The literature cited is relevant, original and recent c. The structure of the introduction demonstrates exceptional insight into the topic, the introduction is structured from an original but very functional perspective d. The objectives are formulated in a very clear manner and are challenging but feasible within the time frame of the study	e. The applied methods are exceptionally well defined f. The relevance of the applied methods for achieving the objectives is demonstrated clearly; limitations of the methods are stated exceptionally well	g. The results obtained are processed exceptionally well and analysed critically, and the analysis is of an exceptionally high level h. The results are presented in an exceptionally clear and logical manner, and only the relevant results are displayed i. The discussion places the obtained results within a broader scientific context and shows exceptional insight into the background of the research j. The discussion is pleasant to read, comprehensive, yet 'to the point'	k. Exceptionally smooth and pleasurably readable text, logical and coherent structure l. Perfect linguistic usage m. Tables, figures and graphs of exceptional quality and perfectly integrated into the text n. Perfect use of references o. High-quality summary that very clearly reflects the structure and conclusions of the study
17-18 highest honours	a. Outstanding positioning of the topic within the broader scientific context, most of the cited literature is critically interpreted and processed by the student b. The cited research is relevant and recent c. The structure of the introduction demonstrates outstanding insight into the topic d. The objectives are clearly formulated and feasible within the time frame of the study	e. The applied methods are very clearly defined f. The relevance of the applied methods for achieving the objectives is demonstrated; limitations of the methods are stated very clearly	g. The results obtained are processed in an outstanding manner and analysed critically, and the analysis is of an outstanding level h. The results are presented clearly and logically, and only the relevant results are displayed i. The discussion places the obtained results within a broader scientific context and shows good insight into the background of the research j. The discussion is pleasant to read and comprehensive	k. Smoothly readable text with a logical and coherent structure l. Very good linguistic usage m. Tables, figures and graphs of very good quality and very well integrated into the text n. Very good use of references o. High-quality summary that clearly reflects the structure and conclusions of the study
15-16- high honours	a. Very good positioning of the topic within the broader scientific context; a portion of the cited literature is critically interpreted and processed by the student b. The cited research is relevant c. The structure of the introduction demonstrates very good insight into the topic d. The objectives are clearly defined	e. The applied methods are clearly defined f. The limitations of the method are discussed clearly to a certain extent	g. The results obtained are processed and analysed very well h. The results are presented clearly, but some of the results presented are not relevant i. The discussion demonstrates insight into the background of the research j. The discussion is pleasant to read	k. Easily readable text, logically structured l. Good linguistic usage m. Tables, figures and graphs of good quality and well integrated into the text n. Good use of references o. Good summary
13-14 honours	a. The topic is well situated within the broader scientific context, and the literature is interpreted critically to a limited extent by the student b. The cited research is largely relevant c. The structure of the introduction demonstrates good insight into the topic d. The objectives are formulated	e. The applied methods are present and defined to a limited extent f. The limitations of the method are discussed to a minimal extent	g. The results obtained are processed and analysed well h. The results are presented clearly enough, but not all of the presented results are relevant i. The discussion demonstrates limited insight into the background of the research j. The discussion is pleasant to read, but lacks some essential points or is not always clear	k. Easily readable text with a largely logical structure l. Occasional grammatical errors m. Tables, figures and graphs can be clearer and better integrated (more info ...) n. Good use of references o. Solid summary
10-12 pass	a. The subject is situated within the broader scientific context to a limited extent; the literature is barely interpreted by the student b. The cited research is not entirely relevant or recent c. The structure of the introduction demonstrates limited insight into the topic d. The objectives are unclear/incomplete	e. The applied methods are present but not clearly defined f. The limitations of the method are not discussed	g. The results obtained are insufficiently processed and analysed h. The results are presented incorrectly in part i. The discussion demonstrates very limited insight into the background of the research j. The discussion is difficult to read and misses essential points or is not clear	k. Text is acceptable, but not easily readable and has no clear structure l. Multiple grammatical errors m. Tables, figures and graphs can be clearer and are not well integrated into the text n. Limited use of references o. Summary does not accurately reflect the structure and conclusions of the research
<10 fail mark	a. The topic is incorrectly situated within the broader scientific context; the literature is not interpreted by the student b. The cited research is not relevant c. The structure of the introduction demonstrates very limited insight into the topic d. The objectives are not reflected accurately	e. The applied methods are not presented correctly or they are missing f. The limitations of the method are discussed incorrectly	g. The found data are not processed and analysed, or they are processed and analysed incorrectly h. The results are presented incorrectly i. The discussion demonstrates incorrect insight into the background of the research j. The discussion is very difficult to read and misses essential points or is not clear	k. Very unclear text l. Frequent grammatical errors m. Tables and figures and graphs are unclear or incorrect n. Incorrect use of references o. Summary is unclear or absent