RESEARCH PAPER

Perceptions, knowledge and attitudes about COVID-19 vaccine hesitancy in older Portuguese adults

Tânia Magalhães Silva[1], Marta Estrela[1], Vítor Roque[2], Eva Rebelo Gomes[3], Adolfo Figueiras[4,5], Fátima Roque[2,6], Maria Teresa Herdeiro[1]

[1]iBiMED – Institute of Biomedicine, Department of Medical Sciences, University of Aveiro, Aveiro, Portugal
[2]Research Unit for Inland Development, Guarda Polytechnic Institute (UDI-IPG), Guarda, Portugal
[3]Allergy and Clinical Immunology Service, University Hospital Center of Porto, Porto, Portugal
[4]Health Research Institute of Santiago de Compostela (IDIS), University of Santiago de Compostela, Santiago de Compostela, Spain
[5]Consortium for Biomedical Research in Epidemiology and Public Health (CIBER Epidemiology and Public Health - CIBERESP), Santiago de Compostela, Spain
[6]Health Sciences Research Center, University of Beira Interior (CICS-UBI), Covilhã, Portugal

Address correspondence to: Tânia Magalhães Silva, iBiMED – Institute of Biomedicine, Department of Medical Sciences, University of Aveiro, Campos Universitário de Santiago, Agra do Crasto – Edifício 30, 3810 - 193 Aveiro, Portugal. Tel: +351 234 372000 (extension 22153). Email: tania.m.silva@ua.pt

Abstract

Background: Coronavirus 2019 (COVID-19) has become a public-health emergency of international concern. Most efforts to contain the spread and transmission of the virus rely on campaigns and interventions targeted to reduce Vaccine Hesitancy and Refusal (VHR).
Objective: this study aims to assess the major factors associated with VHR in the older population in Portugal.
Methods: a nation-wide cross-sectional study was conducted in the older Portuguese population ($\geq$65 years old) through computer-assisted telephone interviewing. Logistic regression was used to determine the adjusted odds ratio (OR) of the independent variables (perceptions, knowledge and attitudes) and of the outcome (VHR).
Results: the response rate was 60.1% (602/1,001). Perceptions, knowledge and attitudes were strongly associated with VHR probability. A 1-point Likert scale increase in concerns about the vaccines' efficacy and safety increased the risk of VHR by 1.96 (95% confidence interval [CI]: 1.40–6.28) and 3.13 (95%CI: 2.08–8.22), respectively. A reduction of VHR probability for 'reliability of the information released by social media' (OR = 0.34, 95%CI: 0.16–0.70) and for 'trust in national and international competent authorities' (OR = 0.34, 95%CI: 0.17–0.69) is also observed per 1-point increase.
Conclusions: as VHR seems to be strongly associated with perceptions, knowledge and attitudes, the design and promotion of vaccination campaigns/educational interventions specifically targeted at changing these potentially modifiable determinants may help to tackle COVID-19 VHR and achieve a wider vaccine coverage.

Keywords: COVID-19, Portugal, older adults, vaccination, hesitancy, older people

Key Points

- A national-wide study was conducted to assess the determinants for vaccination hesitancy and refusal (VHR) among older adults.
- Perceptions, knowledge, and attitudes were strongly associated with COVID-19 VHR.
- Concerns about the safety and efficacy of the COVID-19 vaccines are strong predictors for higher VHR rates.
- Trust on the information released by the media and competent authorities are strongly associated to lower VHR rates.

Introduction

To control and prevent the spread of the COVID-19 pandemic, mass vaccination campaigns are a key element. However, the success of these campaigns will largely depend on the vaccination coverage achieved within the population [1, 2]. It has been shown that vaccination coverage rates are frequently under the recommended levels to limit the spread and reduce the burden of vaccine-preventable diseases on healthcare systems.

Vaccine hesitancy and refusal (VHR) [3] is described as the reluctance or refusal to vaccinate despite the availability of vaccines, and it was identified as 1 of the 10 major threats to global health in 2019 [4]. VHR is usually caused by doubts, distrust and worries/fears concerning vaccine efficacy, protection and safety [5–8], and is greatly influenced by the media [8, 9], particularly among older people. The speed of development and approval of the several COVID-19 vaccines, the lack of a long-term safety and efficacy records, and the way misinformation was initially spread may have led to a rise in VHR [10]. However, to combat this pandemic, population vaccination against SARS-CoV-2 is imperative, aiming to immunise the population as quickly as possible [11–13].

One of the major risk factors for severe COVID-19 disease is age [14–19]. Therefore, older people, together with those with underlying chronic health conditions, are prioritised to receive the COVID-19 vaccine, as they are more likely to develop a serious form of the illness, if infected. Moreover, adverse health outcomes triggered by COVID-19 infection also increase among older adults, such as hospitalisation, intensive care unit admissions and mortality [16–18].

Therefore, the decision to get vaccinated is especially critical among these older adults. Our study aims to assess the main determinants (perceptions, knowledge and attitudes, as well as sociodemographic factors) that influence the Portuguese older population on COVID-19 vaccination hesitancy and refusal.

Methods

Setting

This study was carried out in mainland Portugal, with a population of around 10.3 million inhabitants [20]. This study, involving older adults (≥65 years old) from the general population, was conducted between April and May 2021, a period in which the first COVID-19 vaccines had already been recommended for authorisation in Europe by the European Medicines Agency (EMA) [21] and the vaccination of the Portuguese older population had already been initiated. The reason for choosing this at-risk population was related to their priority in receiving the COVID-19 vaccine [22].

In Portugal, COVID-19 vaccination has started in December, 2020 and, until now, only four vaccines were approved for emergency use: (i) Pfizer/BioNTech:BNT162b2, (ii) Moderna:mRNA-1273, (iii) Oxford/AstraZeneca:AZD1222—now being the recommended vaccine for adults over 60 years old [23] and (iv) Janssen(Johnson&Johnson):Ad26.COV2.S [24]. Since the beginning of the vaccination process, the non-institutionalised older adults were contacted by the health services to schedule their vaccination.

Study design

A cross-sectional study was carried out in a Portuguese population sample of older adults (≥65 years old) from mainland Portugal, through computer-assisted telephone interviewing (CATI) by the company GAPS Politics and Society SL. The database was supplied by an international company using a random and automatic dial process based on the country's numbering plan, distributed by regions in proportion to the population. This database does not include any personal information, respecting the General Data Protection Regulations (GDPR). The distribution of the resident population in 2019, including by age range, was obtained from the Statistics Portugal web portal on 7 April 2021 [25]. For this study, as the surveys were applied according to the population living in mainland Portugal with ≥65 years old, the calculation of the population's distribution was performed accordingly.

The sample size calculation assumed an expected proportion of intention to be vaccinated of 66% (based on the flu vaccination coverage for groups at-risk, [26]), and a precision of 4% in either direction.

Data collection

A questionnaire was designed based on an extensive bibliographic review [27, 28] and also on focus groups, conducted with teachers and health professionals. Afterwards, considering the information obtained from the literature, the questionnaire was developed, and its face and content validity were assessed by a multidisciplinary panel, composed by epidemiologists, pharmacologists and public health experts.

The questionnaire was divided into three sections and its completion took no longer than 10–15 min. The sections included:

a. Questions about the sociodemographic characteristics of the participants (sex, age group, education level, household composition, geographical region);
b. Six questions concerning the evaluation of the overall health condition of the respondents, their vaccination status, and if they belong to a risk group;
c. Some questions to assess participants' perceptions, knowledge, and attitudes regarding the vaccines against SARS-CoV-2, namely the existing barriers to vaccination, the efficacy of the vaccine, and the vulnerabilities and worries related to vaccination. These variables were measured using a 4-point Likert scale (from strongly disagree to strongly agree).

The telephone interviews were conducted between 21 April and 10 May 2021.

Variables definition

A new composite dependent variable (VHR) was created through the evaluation of the three following questionnaire items:

- 'Have you already been vaccinated against COVID-19?';
- 'In case you haven't, why not?';
- 'Once the COVID-19 vaccine is available for you, will you get it?'.

VHR was considered to take the value 1 when the older adult was not vaccinated and had no intention to get the vaccine; taking the value 0 in the remaining cases (has already been vaccinated, has not been vaccinated but the vaccine is scheduled, or has the intention to get the vaccine) (see Figure 2).

Statistical analysis

A binary logistic regression analysis was computed to model the associations between independent variables and COVID-19 VHR. The model assessed the crude risk of VHR taking account of perceptions, knowledge and attitudes, adjusted for statistically significant ($P < 0.1$) personal sociodemographic and health condition variable. Results were expressed as odds ratios (ORs) with their 95% confidence intervals (CIs) and correlated P-value (for which the level of statistical significance was set to $P < 0.05$).

Ethics

This study was conducted by GAPS Politics and Society SL, having as basis the contract established with 'la Caixa' Foundation, which is following the Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of individuals with regard to the processing of personal data and the free movement of such data, and which repeals Directive 95/46/EC (GDPR). In addition, GAPS is a member of the European Society for Opinion and Marketing Research (ESOMAR). Participation on the study was volunteer and participants gave their informed consent before participation. The responses given were completely anonymous and confidential and were exclusively used for this study.

Results

Of the total of 8,103 telephone calls made, 4,989 were not answered, 1,064 were incorrect phone numbers, 1,049 corresponded to people with less than 65 years old (not part of our target population) and the remaining refused to participate. In the end, a total of 602 valid surveys were completed, as shown in Figure 1.

Figure 2 illustrates the construction of the dependent variable:

The response rate was over 60% (Figure 1). More than 65% of the older adults were already vaccinated against COVID-19, and around 3.3% did not want or had no intention to get the vaccine (Figure 2).

Table 1 displays the sociodemographic characteristics and health condition status of the population sample under study and their influence on VHR. In the fully adjusted analysis, only households with one family member aged less than 18 years old appear to be more susceptible to VHR ($P < 0.05$).

Table 2 shows that several perceptions, knowledge and attitudes are strongly associated to a higher or lower predisposition to be vaccinated. For each point increase on the Likert scale, the probability of VHR increases by about 3-fold (OR = 2.96, 95%CI: 1.40–6.28) for 'I am concerned about the vaccine's efficacy' and by more than 4-fold (OR = 4.14, 95%CI: 2.08–8.22) for 'I am concerned about the vaccine's possible side effects'.

Table 2 also shows that being aware of the benefits of receiving the COVID-19 vaccine (S3–S6: knowledge about the serious complications that may arise from a COVID-19 infection (OR = 0.16, 95%CI: 0.07–0.38), the importance of vaccination to decrease the probability of being infected and suffering complications (OR = 0.21, 95%CI: 0.09–0.45 and OR = 0.34, 95%CI: 0.12–0.96, respectively), and the concerns about getting an infection (OR = 0.14, 95%CI: 0.06–0.32) has a significant inverse relationship with VHR probability. Hence, a 1-point increase of the Likert-scale reduces the probability of VHR.

Regarding the influence of the perceived quality of the information disclosed by participants, Table 2 shows that a 1-point increase in the Likert scale in the statements 'I believe that the information released on the social media is reliable' and 'I believe that the information released by the competent authorities is reliable' decreases the propensity for VHR (OR = 0.34, 95%CI: 0.16–0.70, and OR = 0.34, 95%CI: 0.17–0.69, respectively). Furthermore, a 1-point increase in the Likert scale decreases the probability of VHR (OR = 0.39, 95%CI: 0.20–0.75), in the case of being confident that the COVID-19 pandemic ends when most of the population gets vaccinated.

Discussion

With herd immunity elusive, vaccination constitutes the best defence against COVID-19 [29]. However, refusing vaccination may prevent COVID-19 vaccines from achieving sufficient immunisation coverage to end the global pandemic [30]. To our knowledge, this is the first study assessing the main perceptions, knowledge and attitudes of the Portuguese older adults towards non-vaccination against COVID-19. As these are potentially modifiable variables, our results may aid in designing and developing educational interventions specifically targeted to reduce VHR among the older population.

The only determinant regarding the participants' sociodemographic characteristics which may likely influence vaccination intention, is having one family member aged less
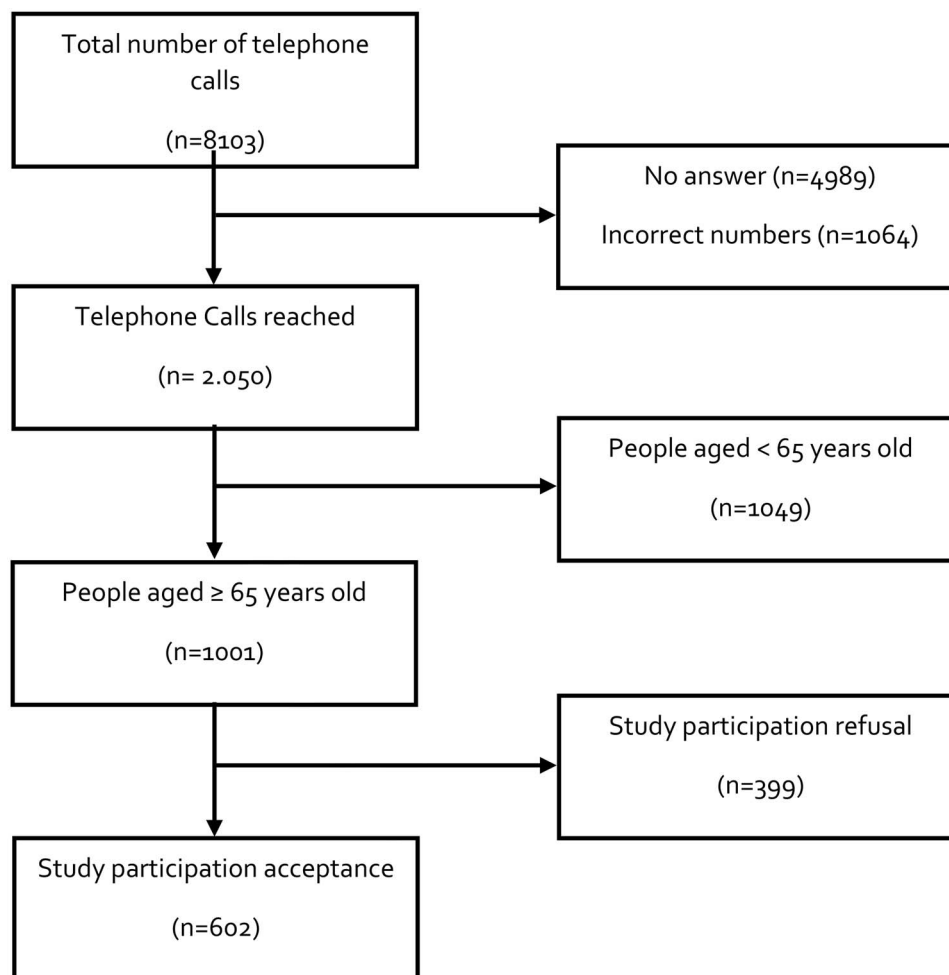
Figure 1. Flow diagram of the cross-sectional study.

than 18 years old in the household. In these cases, older adults are 14.5 times more prone to refuse vaccination or having no intention to get the vaccine. Possible explanatory reasons may include the influence of the younger family members, as in another study assessing the factors associated with COVID-19 VHR in Portugal, a higher odds of vaccine refusal was also found for persons with school-age children at home [31]. Other reasons may be related to the lack of information on the vaccine benefits or perception of the information provided as inconsistent or contradictory among this group [31, 32].

The analysis of the perceptions, knowledge and attitudes of the Portuguese older adults revealed an interesting series of factors that may have a positive effect on COVID-19 vaccination acceptance and intention, such as:

- knowing that the complications arising from a COVID-19 infection are serious (OR = 0.16) (S3);
- perceiving that vaccination decreases both the probability of getting a COVID-19 infection (OR = 0.21) (S4) and suffering from associated complications (OR = 0.34) (S6);
- feeling less worried about getting infected after taking the vaccine (OR = 0.14) (S5);

- and believing that vaccination can put an end to the pandemic (OR = 0.39) (S15).

These predictors of vaccination intent have been previously shown [33, 34], and have demonstrated that people became more willing to accept the COVID-19 vaccine when the perception of the infection risk and disease severity increases. Another recent study has revealed that the intention to get the vaccine can also be associated to an interest in personal protection and well-being against COVID-19 infection, particularly in low- to middle-income countries [30].

We found that the older population trusts the information released by the social media (OR = 0.34) (S13) and competent national and international authorities (OR = 0.34) (S14), leading to a decrease in VHR. In fact, social media has been widely used worldwide as the main source of COVID-19 information [9, 35, 36], hence being essential that it delivers trustful and evidence-based vaccine information, as extensive anti-vaccine content is frequently shared across social media, thus negatively impacting vaccination intention [9]. These results are in line with findings from
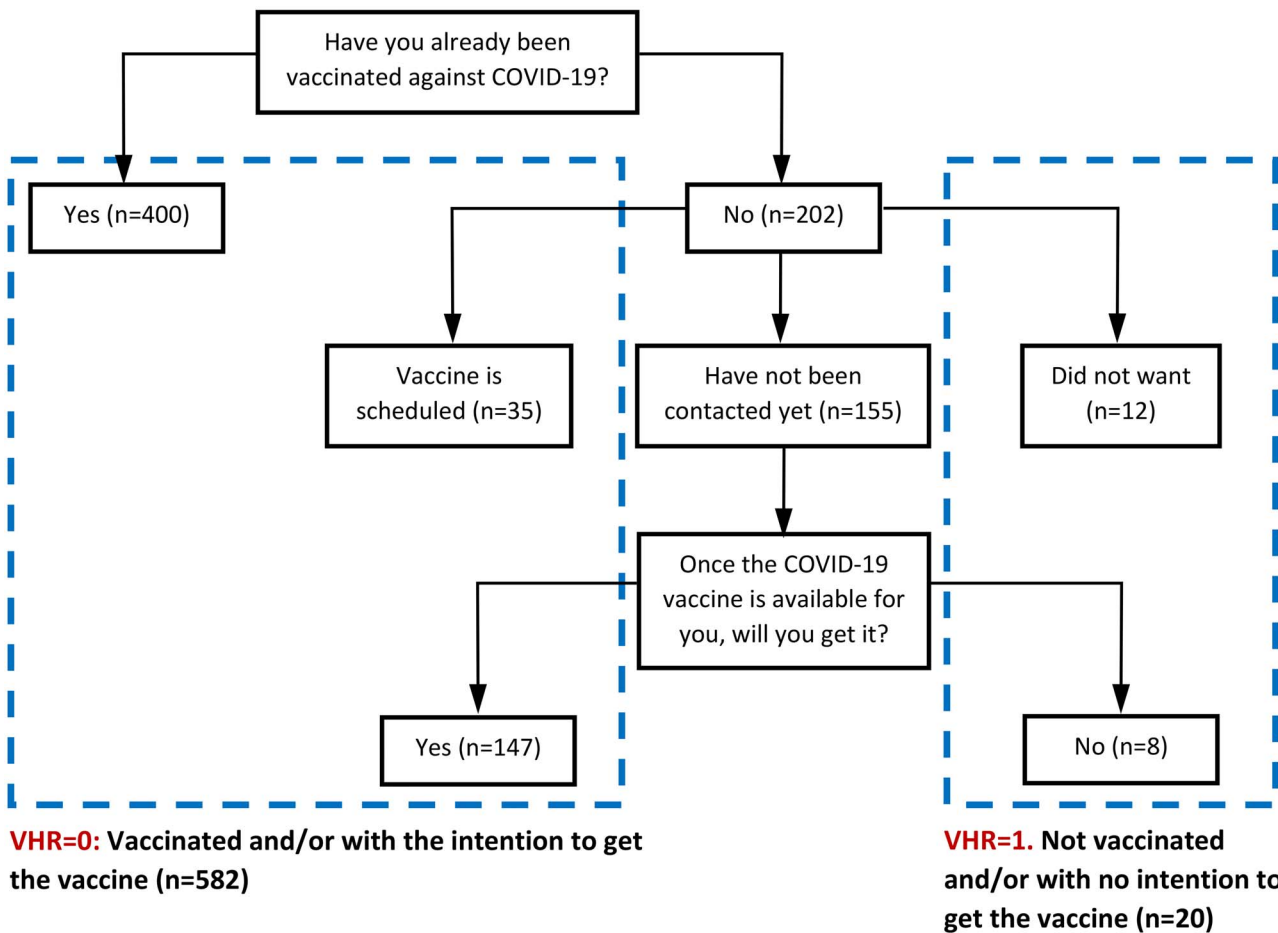
Figure 2. Definition of the composed variable (VHR) by taking into consideration three different questionnaire items related to the vaccination refusal/acceptance and/or with no intention/intention to get the COVID-19 vaccine.

similar studies where the competent authorities, such as the Centre for Disease Control and Prevention, WHO [37] and national health authorities [1], have been shown to be key drivers of COVID-19 vaccine acceptance, as the confidence in the endorsements by these organisations make the population more willing to take the vaccine.

A task force for COVID-19 vaccination has been coordinating the vaccination process since its beginning, defining priority groups and vaccines' distribution [38, 39], and, by the beginning of October 2021, over 85% of the total Portuguese population was fully vaccinated [40], thus becoming the leading country in the world with the highest vaccination coverage rate [41]. Throughout the vaccination process, the media outlets disseminated the various statements released by the competent authorities daily, helping to disseminate reliable information among the population, namely those from the Directorate-General of Health representatives. However, it is important to emphasise that Portugal was already one of the countries with the highest influenza vaccine coverage in Europe, [42]—which may have had a role in the reduced number of vaccine-hesitant older adults. Thus, previous public health measures to enhance vaccine coverage regarding other infectious diseases, might

have influenced the trust in the COVID-19 vaccine, when comparing with vaccination coverage rates in other countries.

Our results also indicate that the two most important determinants for refusing or not having the intention to get the vaccine were the worries/concerns about its efficacy (OR = 2.96) (S7) and perceived safety (OR = 4.14) (S8). These findings are in agreement with previous studies performed in Portugal [31] and in other countries [10, 30, 35, 43–46], where these same two factors were leading causes of VHR. A previous study with Swiss older adults shown that those unsure or against vaccination would rather prefer to maintain the protecting measures (hand hygiene and mask use) than be vaccinated [10]. Moreover, the rare but severe cases of thrombosis and concerns around potential increased risk of blood clots from the AstraZeneca vaccine may have also increased the older adults' VHR levels [30, 43].

These results may impact the way we approach the problem of VHR in general, but particularly among older adults. As research on human coronaviruses suggests that lifetime immunity is unlikely [47, 48], it becomes extremely important to combat VHR. This can be achieved by identifying the main factors associated to VHR, aiming

Table 1. Influence of the study population sociodemographic characteristics and health condition on COVID-19 VHR (adjusted OR)

		COVID-19 vaccination intention N (%)		Crude analysis		Adjusted analysis[a]	
		Yes	No	OR	95% CI	OR	95% CI
Sociodemographic characteristics/information							
Sex	Male	242 (97.6)	6 (2.4)	1.00		1.00	
	Female	340 (96.0)	14 (4.0)	1.66	0.63, 4.38	1.20	0.41, 3.46
Age group	65–79	412 (96.5)	15 (3.5)	1.00		1.00	
(years)	≥80	170 (97.1)	5 (2.9)	0.81	0.29, 2.26	0.75	0.25, 2.25
Education level	None	47 (95.9)	2 (4.1)	1.00		1.00	
	Lower secondary education	426 (97.3)	12 (2.7)	0.73	0.16, 3.37	0.56	0.11, 2.91
	Upper secondary education	37 (92.5)	3 (7.5)	0.90	0.15, 5.61	0.60	0.08, 4.77
	University	72 (96.0)	3 (4.0)	0.98	0.16, 6.08	0.77	0.11, 5.59
Household family	1	133 (95.7)	6 (4.3)	1.00		1.00	
members	2–3	392 (97.3)	11 (2.7)	0.62	0.23, 1.72	0.61	0.20, 1.82
	4–5	45 (95.7)	2 (4.3)	0.99	0.19, 5.06	0.26	0.03, 2.53
	>5	12 (92.3)	1 (7.7)	1.85	0.21, 16.64	1.04	0.02, 46.37
Family members	0	550 (97.2)	16 (2.8)	1.00		1.00	
< 18 years old	1	15 (83.3)	3 (16.7)	6.88	1.81, 26.14	14.52	2.25, 94.02
	≥2	17 (94.4)	1 (5.6)	2.02	0.25, 16.14	1.97	0.05, 83.15
Geographical region	North	197 (96.6)	7 (3.4)	1.00		1.00	
	Centre	147 (98.0)	3 (2.0)	0.57	0.15, 2.26	0.56	0.14, 2.31
	Lisbon Metropolitan Area	167 (96.5)	6 (3.5)	1.01	0.33, 3.07	0.92	0.28, 2.99
	Alentejo	48 (98.0)	1 (2.0)	0.59	0.07, 4.88	0.56	0.06, 4.96
	Algarve	23 (88.5)	3 (11.5)	3.67	0.89, 15.18	3.00	0.62, 14.42
Health condition Auto-evaluation							
Health condition	Very good	31 (91.2)	3 (8.8)	1.00		1.00	
classification	Good	200 (97.6)	5 (2.4)	0.26	0.06, 1.14	0.25	0.05, 1.21
	Reasonable	259 (97.4)	7 (2.6)	0.28	0.07, 1.14	0.29	0.06, 1.38
	Weak/Poor	73 (94.8)	4 (5.2)	0.57	0.12, 2.68	0.63	0.11, 3.82
	Very weak/Very poor	19 (95.0)	1 (5.0)	0.54	0.05, 5.61	0.31	0.02, 4.89
Diagnosis of chronic	No	307 (97.2)	9 (2.8)	1.00		1.00	
disease[b]	Yes	275 (96.2)	11 (3.8)	1.36	0.56, 3.34	1.32	0.47, 3.69

[a]Adjusted for the effects of the other variables included in the table. [b]See Supplementary Table S1 for the effects of individual chronic diseases on VRH. OR = odds ratio; CI = confidence interval.

to design and develop targeted vaccination campaigns or educational interventions, that should highlight the protection effects and other benefits provided by COVID-19 vaccines. The promotion of these interventions would be essential, as they could lead to significant improvements in immunisation coverage rates. Strategies to enhance vaccine literacy and acceptance that directly focus on community-specific worries and needs to build confidence in different contexts, and educating the public about the need for universal vaccine coverage, should also take these findings into consideration [46].

The current research presents several strengths and limitations. The contribution of older adults with different health condition statuses provided diverse perceptions, knowledge and attitudes about COVID-19 vaccination across different settings. Furthermore, perspectives from the study population were obtained from various parts of mainland Portugal, providing input from different geographical locations. CATI does not require literate participants and presents a high accuracy in data collection, at the same time as it makes the interviewing process much quicker [49, 50].

Still, the interpretation of the results must be carefully considered since this is a cross-sectional study, where causal inferences cannot be drawn. Moreover, some vulnerable older adults may have been underrepresented, since the use of CATI to reach this target audiences is becoming more difficult, and our study did not include home resident older adults. Nevertheless, a 60% response rate has been achieved, being a very high response rate for this type of data collection [51]. Though we do not know the perceptions of 40% of the sample, which possibly affects the statistical representativeness of the sample, in terms of scientific research, and according to Rothman [52], the generalisation is not dependent on the statistical representativeness of the sample, but on the mechanisms implied in the detected association of the phenomenon under study [52–54].

Another limitation of our study is that, when data were collected—and for confidentiality reasons—only two groups (65-79 and + 80) were considered. One might think that this could be a limitation, as we do not have enough data to compare with the Portuguese population over 65 years old, as we do not know to what extent the subjects studied are representative by age of the Portuguese population. Still, as the main objective of our study is to assess the impact of perceptions, knowledge, and attitudes on VHR, and since the relationship between the exposure and the effects

Table 2. Influence of the perceptions, knowledge and attitudes of older adults (≥65 years old) on COVID-19 VHR. Adjusted OR per 1-point in Likert scale of each perception, knowledge and attitudes

Statement	Valid N	Median	Adjusted analysis[a]	
			OR[b]	95% CI
S1. The probability of getting COVID-19 is high.	590	3	0.54	0.22–1.30
S2. I am concerned about the probability of getting COVID-19.	602	3	0.57	0.26–1.27
S3. The complications from COVID-19 are serious.	601	3	0.16	0.07–0.38
S4. The probability of being infected with COVID-19 decreases with vaccination.	588	3	0.21	0.09–0.45
S5. I feel less worried about being infected with COVID-19 if I get vaccinated.	589	3	0.14	0.06–0.32
S6. The probability of suffering complications from COVID-19 decreases with vaccination.	597	3	0.34	0.12–0.96
S7. I am concerned about the vaccine's efficacy.	600	2	2.96	1.40–6.28
S8. I am concerned about the vaccine's possible side effects.	601	2	4.14	2.08–8.22
S9. I will only get the vaccine when most of the population has taken it.	601	2	0.88	0.32–2.44
S10. I am concerned about the vaccine's manufacturer/country of origin.	600	2	1.19	0.52–2.71
S11. I will only get the vaccine if it is required to travel between countries.	602	2	0.73	0.24–2.28
S12. I will only get the vaccine if I obtain sufficient information.	602	3	0.61	0.25–1.48
S13. COVID-19 vaccination: I believe that the information released on the social media is reliable.	587	3	0.34	0.16–0.70
S14. COVID-19 vaccination: I believe that the information released by the competent authorities is reliable.	589	3	0.34	0.17–0.69
S15. I am confident that the pandemic will end when most of the population is vaccinated.	586	3	0.39	0.20–0.75
S16. Even after being infected with COVID-19, I must get the vaccine.	589	3	0.67	0.33–1.39
S17. If infected with COVID-19, I would like to take a test to check my acquired immunity.	590	3	0.77	0.34–1.73
S18. After taking the COVID-19 vaccine, I would like to take a test to check my acquired immunity.	588	3	0.46	0.21–1.01

[a]These data are adjusted for the variables in which the analysis of the sociodemographic variables resulted in $P < 0.1$ (Family members < 18 years old). [b]OR indicates the increase/decrease in VHR (probability of not getting vaccinated or not having the intention to get the vaccine).

remains unchanged by the representativeness of the sample, we believe that if there is a lack of representativeness by age, it would not affect the conclusions of this study [55].

In our case, although our sample may not be representative of the Portuguese older population—neither in terms of age distribution nor other possible characteristics—our main goal was to assess the mechanism underlying the influence of the perceptions, knowledge and attitudes on COVID-19 VHR, so this should not be seen as an important study limitation [52–54]. Still, the low number of subjects with VHR in our sample can also be considered a limitation. Although the statistical analysis performed using multiple logistic regression already considers this low number of subjects to calculate the 95% CIs, it cannot be ruled that part of the effect found may be due to random bias or even systematic error. Thus, we cannot fully exclude the possibility of a response bias, neither assure that every determinant of VHR has been identified, as there were only 20 respondents who were vaccine-hesitant.

However, though the number of people with hesitancy for COVID-19 vaccination is quite small and represents only 3% of the responders, which can be seen as a limitation, we believe that, though 3% of vaccination hesitancy is low in relative terms, it is very high in absolute terms (as there are ∼68,000 inhabitants over 65 years old in Portugal, a country with ∼10.3 M inhabitants). This is a very high figure for a group so vulnerable and under extremely high risk, as these older adults are unprotected and depend entirely on the immunity of the rest of the population and on non-pharmacological measures, such as social distancing and use of masks.

Although the applicability of the results of a knowledge, attitudes and perceptions study such as ours to different settings can be affected by factors dependent on the environment (such as the health system of health authorities and even cultural factors), we have observed a high consistency of the knowledge, attitudes, and perceptions' determinants between settings [56–61].

Although these findings were specific to the population under study—and therefore may not be reproducible in different settings—we believe that the mechanisms underlying the influence of the perceptions, knowledge and attitudes on COVID-19 VHR would possibly be very similar in other contexts. Finally, it is important to consider that the COVID-19 pandemic has been highly dynamic, and so has been the vaccination process and the discoveries throughout this period—namely the knowledge regarding side effects and vaccines' effectiveness. Thus, as the telephone interviews were only conducted for 2 months, we cannot assure that vaccination hesitancy rates would be the same as those in past or future moments, nor the perceptions associated.

Conclusions

The results of this study suggest that the main predictors of VHR among the Portuguese older adults are modifiable factors, namely misbeliefs about the efficacy and safety of COVID-19 vaccination. Hence, this study provides useful

insights on the main determinants influencing COVID-19 vaccination among older adults, particularly the major perceptions, knowledge and attitudes associated to non-vaccination, which should be considered in further research and vaccination campaigns to help mitigate VHR.

References

1. Lindholt MF, Jørgensen F, Bor A *et al.* Public acceptance of COVID-19 vaccines: cross-national evidence on levels and individual-level predictors using observational data. BMJ Open 2021; 11: e048172.
2. Kerr JR, Schneider CR, Recchia G *et al.* Correlates of intended COVID-19 vaccine acceptance across time and countries: results from a series of cross-sectional surveys. BMJ Open 2021; 11: e048025.
3. Adhikari B, Cheah PY. Vaccine hesitancy in the COVID-19 era. Lancet Infect Dis 2021; 21: 1086.
4. World Health Organization. Ten Threats to Global Health in 2019. World Health Organization, 2021.
5. Dror AA, Eisenbach N, Taiber S *et al.* Vaccine hesitancy: the next challenge in the fight against COVID-19. Eur J Epidemiol 2020; 35: 775–9.
6. Paterson P, Meurice F, Stanberry LR *et al.* Vaccine hesitancy and healthcare providers. Vaccine 2016; 34: 6700–6.
7. Dubé E, Laberge C, Guay M *et al.* Vaccine hesitancy. Hum Vaccin Immunother 2013; 9: 1763–73.
8. Siciliani L, Wild C, McKee M *et al.* Strengthening vaccination programmes and health systems in the European Union: a framework for action. Health Policy (New York) 2020; 124: 511–8.
9. Puri N, Coomes EA, Haghbayan H *et al.* Social media and vaccine hesitancy: new updates for the era of COVID-19 and globalized infectious diseases. Hum Vaccin Immunother 2020; 16: 2586–93.
10. Fadda M, Suggs LS, Albanese E. Willingness to vaccinate against Covid-19: a qualitative study involving older adults from southern Switzerland. Vaccine X 2021; 8: 100108.
11. Patel SP, Patel GS, Suthar JV. Inside the story about the research and development of COVID-19 vaccines. Clin Exp Vaccine Res 2021; 10: 154.
12. Motamedi H, Ari MM, Dashtbin S *et al.* An update review of globally reported SARS-CoV-2 vaccines in preclinical and clinical stages. Int Immunopharmacol 2021; 96: 107763.
13. Chung JY, Thone MN, Kwon YJ. COVID-19 vaccines: the status and perspectives in delivery points of view. Adv Drug Deliv Rev 2021; 170: 1–25.
14. Nanda A, Vura NVRK, Gravenstein S. COVID-19 in older adults. Aging Clin Exp Res 2020; 32: 1199–202.
15. Daoust J-F. Elderly people and responses to COVID-19 in 27 countries. PLoS One 2020; 15: e0235590.
16. Chen Y, Klein SL, Garibaldi BT *et al.* Aging in COVID-19: vulnerability, immunity and intervention. Ageing Res Rev 2021; 65: 101205.
17. Soiza RL, Scicluna C, Thomson EC. Efficacy and safety of COVID-19 vaccines in older people. Age Ageing 2021; 50: 279–83.
18. Dhama K, Patel SK, Natesan S *et al.* COVID-19 in the elderly people and advances in vaccination approaches. Hum Vaccin Immunother 2020; 16: 2938–43.
19. Witham MD, Gordon AL, Henderson EJ *et al.* Pandemic research for older people: doing it better next time. Age Ageing 2021; 50: 276–8.
20. Fundação Francisco Manuel dos Santos Pordata. Resident Population, Annual Average: Total and by Sex. Fundação Francisco Manuel dos Santos, 2021. https://www.pordata.pt/en/Portugal/Resident+population++annual+average+total+and+by+sex-6. (15 July 2021, date last accessed).
21. European Medicines Agency. COVID-19 Vaccines: Authorised. European Medicines Agency, 2021. https://www.ema.europa.eu/en/human-regulatory/overview/public-health-threats/coronavirus-disease-covid-19/treatments-vaccines/vaccines-covid-19/covid-19-vaccines-authorised#authorised-covid-19-vaccines-section (3 September 2021, date last accessed).
22. Safe Communities Portugal. Portugal Vaccination Plan. Safe Communities Portugal, 2021. https://www.safecommunitiesportugal.com/wp-content/uploads/2021/01/Vaccination-plan-estamoson-2.pdf (29 July 2021, date last accessed).
23. Razai MS, Oakeshott P, Esmail A *et al.* COVID-19 vaccine hesitancy: the five Cs to tackle behavioural and sociodemographic factors. J R Soc Med 2021; 114: 295–8.
24. McGill COVID19 Vaccine Tracker Team. COVID-19 Vaccine Tracker: Portugal. VIPER Group COVID19 Vaccine Tracker Team, 2021.
25. Statistics Portugal (Instituto Nacional de Estatística I. Demographic Statistics 2019.). Instituto Nacional de Estatística, 2021.
26. Sanofi Portugal. Gripe e Vacinómetro. Sanofi, 2020. https://www.sanofi.pt/pt/atividade-portugal/Sanofi-Pasteur/vacinometro (12 October 2020, date last accessed).
27. Weinstein ND, Kwitel A, McCaul KD *et al.* Risk perceptions: assessment and relationship to influenza vaccination. Health Psychol 2007; 26: 146–51.
28. Lin Y, Hu Z, Zhao Q *et al.* Understanding COVID-19 vaccine demand and hesitancy: a nationwide online survey in China. PLoS Negl Trop Dis 2020; 14: e0008961.
29. Aschwanden C. Five reasons why COVID herd immunity is probably impossible. Nature 2021; 591: 520–2.
30. Solís Arce JS, Warren SS, Meriggi NF *et al.* COVID-19 vaccine acceptance and hesitancy in low- and middle-income countries. Nat Med 2021; 27: 1385–94.
31. Soares P, Rocha JV, Moniz M *et al.* Factors associated with COVID-19 vaccine hesitancy. Vaccine 2021; 9: 300.

32. Bhagianadh D, Arora K. COVID-19 vaccine hesitancy among community-dwelling older adults: the role of information sources. J Appl Gerontol 2021; 073346482110375.

33. Caserotti M, Girardi P, Rubaltelli E et al. Associations of COVID-19 risk perception with vaccine hesitancy over time for Italian residents. Soc Sci Med 2021; 272: 113688.

34. Ruiz JB, Bell RA. Predictors of intention to vaccinate against COVID-19: results of a nationwide survey. Vaccine 2021; 39: 1080–6.

35. Mohamed NA, Solehan HM, Rani MDM et al. Knowledge, acceptance and perception on COVID-19 vaccine among Malaysians: a web-based survey. PLoS One 2021; 16: e0256110.

36. Ali KF, Whitebridge S, Jamal MH et al. Perceptions, knowledge, and behaviors related to COVID-19 among social media users: cross-sectional study. J Med Internet Res 2020; 22: e19913.

37. Kreps S, Prasad S, Brownstein JS et al. Factors associated with US adults' likelihood of accepting COVID-19 vaccination. JAMA Netw Open 2020; 3: e2025594.

38. Direção-Geral da Saúde. Norma 002/2021 - Campanha de Vacinação Contra a COVID-19. Direção-Geral da Saúde, 2021.

39. Direção-Geral da Saúde. DGS publica norma sobre a Fase 1 da Campanha de Vacinação contra a COVID-19 - COVID-19. DGS. Direção-Geral da Saúde, 2021.

40. Direção-Geral da Saúde. Relatório de Vacinação - Semana 35. Direção-Geral da Saúde, 2021.

41. Mathieu E, Ritchie H, Ortiz-Ospina E et al. A global database of COVID-19 vaccinations. Nat Hum Behav 2021; 5: 947–53.

42. OECD. Health at a Glance: Europe 2020. Organisation for Economic Co-operation and Development, 2020.

43. Prickett KC, Habibi H, Carr PA. COVID-19 vaccine hesitancy and acceptance in a cohort of diverse new Zealanders. Lancet Reg Heal - West Pacific 2021; 14: 100241.

44. Razai MS, Chaudhry UAR, Doerholt K et al. Covid-19 vaccination hesitancy. BMJ 2021; 373. https://doi.org/10.1136/BMJ.N1138.

45. Fares S, Elmnyer MM, Mohamed SS et al. COVID-19 vaccination perception and attitude among healthcare workers in Egypt. J Prim Care Community Health 2021; 12.

46. Lazarus JV, Ratzan SC, Palayew A et al. Author correction: A global survey of potential acceptance of a COVID-19 vaccine. Nat Med 2021; 27: 354.

47. The Conversation. How Long Does Immunity Last After COVID Vaccination? Do We Need Booster Shots? 2 Immunology Experts Explain. The Conversation, 2021 https://theconversation.com/how-long-does-immunity-last-after-covid-vaccination-do-we-need-booster-shots-2-immunology-experts-explain-164073 (3 August 2021, date last accessed).

48. Abbasi J. Study suggests lasting immunity after COVID-19, with a big boost from vaccination. JAMA 2021; 326: 376.

49. Computer-Assisted Telephone Interviewing (CATI). Encyclopedia of Survey Research Methods. 2455 Teller Road, Thousand Oaks California 91320 United States of America: Sage Publications, Inc.

50. Gibson DG, Pereira A, Farrenkopf BA et al. Mobile phone surveys for collecting population-level estimates in low- and middle-income countries: a literature review. J Med Internet Res 2017; 19: e139.

51. O'Toole J, Sinclair M, Leder K. Maximising response rates in household telephone surveys. BMC Med Res Methodol 2008; 8: 1–5.

52. Rothman KJ, Gallacher JE, Hatch EE. Why representativeness should be avoided. Int J Epidemiol 2013; 42: 1012–4.

53. Alonso A, de Irala J, Martínez-González MA. Representativeness, losses to follow-up and validity in cohort studies. Eur J Epidemiol 2007; 22: 481–2.

54. Richiardi L, Pizzi C, Pearce N. Commentary: representativeness is usually not necessary and often should be avoided. Int J Epidemiol 2013; 42: 1018–22.

55. Fry A, Littlejohns TJ, Sudlow C et al. Comparison of sociodemographic and health-related characteristics of UK biobank participants with those of the general population. Am J Epidemiol 2017; 186: 1026–34.

56. Roque F, Soares S, Breitenfeld L et al. Influence of community pharmacists' attitudes on antibiotic dispensing behavior: a cross-sectional study in Portugal. Clin Ther 2015; 37: 168–77.

57. Rodrigues AT, Nunes JCF, Estrela M et al. Comparing hospital and primary care physicians' attitudes and knowledge regarding antibiotic prescribing: a survey within the Centre region of Portugal. Antibiotics 2021; 10: 629.

58. Marques JIOM, Polónia JMJ, Figueiras AG et al. Nurses' attitudes and spontaneous adverse drug reaction reporting: a case–control study in Portugal. J Nurs Manag 2016; 24: 409–16.

59. Plácido AI, Herdeiro MT, Simões JL et al. Health professionals perception and beliefs about drug- related problems on polymedicated older adults- a focus group study. BMC Geriatr 2021; 21: 27.

60. Plácido AI, Herdeiro MT, Simões JL et al. Voices of polymedicated older patients: a focus group approach. Int J Environ Res Public Health 2020; 17: 6443.

61. Paiva AR, Plácido AI, Curto I et al. Acceptance of pharmaceutical services by home-dwelling older patients: a case study in a Portuguese community pharmacy. Int J Environ Res Public Health 2021; 18: 7401.