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ORIGINAL ARTICLE

Psychological antecedents toward COVID-19 vaccination explain the high rates of vaccine rejection among the Libyan population 2 years after starting vaccination campaigns

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Abstract

Background Libya has one of the lowest rates of coverage of the coronavirus diseases 2019 (COVID-19) vaccination in the Eastern Mediterranean Region. This study aims to explore the attitudes of the Libyan population toward COVID-19 vaccines and identify the psychological factors that influence their decision-making process regarding vaccination.

Methods An anonymous online survey was distributed among the Libyan population, utilizing the validated English and Arabic versions of the 5C scale. The survey was distributed through various social media platforms. The snowball and convenience sampling methods were used to collect data from participants, who were categorized as either vaccine acceptors or vaccine rejectors.

Results Of the 1838 participants, 39.2% fell within the age range of 25 to 34 years and 68.2% were female. Only 26% of the respondents had either received the COVID-19 vaccination or had a plan to do so. Four-fifths (80.0%) of the participants expressed confidence in COVID-19 vaccines, 91.1% felt complacent about vaccination, 78.4% faced constraints, 93.9% made calculations to receive the COVID-19 vaccine, and 93.6% felt collective responsibility toward getting vaccinated. Significant statistical differences were identified in the various 5C domains between vaccine acceptors and rejectors. Specifically, there were notable disparities in confidence (95.65% vs. 68.64%, $p < 0.001$), constraints (51.39% vs. 80.29%, $p < 0.001$), calculation (92.86% vs. 72.83%, $p < 0.001$), and collective responsibility (95.73% vs. 72.57%, $p < 0.001$) between the two groups. Multivariate analysis showed that older age [35–49 years or 50–65 years], being male, having confidence, and having collective responsibility positively affected COVID-19 vaccination [odds ratio (OR) = 0.61, 95% confidence interval (CI), 0.41–0.89, OR = 0.31 (95% CI, 0.15–0.62), OR = 0.54 (95%CI, 0.42–0.70), OR = 0.14, (95%CI, 0.08–0.23), OR = 0.19 (95%CI, 0.06 – 0.48)], respectively], while working in crafts and related trade work and constraints negatively affected COVID-19 vaccination [OR = 1.86 (95%CI, 1.10–3.22), OR = 4.98 (95%CI, 3.77–6.60.27), respectively].

Conclusions Vaccine rejection can be influenced by various non-modifiable factors such as age and sex. However, psychological factors, including confidence, constraints, and collective responsibility, play a significant role and can be targeted and modified to reduce vaccine rejection among Libyans.

Keywords COVID-19 vaccine hesitancy · Psychological antecedents · 5C scale · Eastern Mediterranean Region · Libya

Introduction

The World Health Organization (WHO) guided the world to implement different public health and social measures (PHSMs) such as quarantine, social distancing, wearing masks, and travel restrictions to contain this pandemic (World Health Organization 2020). Although these measures showed a significant impact on lowering the coronavirus diseases 2019 (COVID-19) incidence and mortality rates, their implementation caused significant social burdens (Demirgüç-Kunt et al. 2021; Ghazy et al. 2022d), many psychological implications (Abd ElHafeez et al. 2022; Li et al. 2021; Pedrosa et al. 2020), and severe economic recession (Nicola et al. 2020).

Clinical pharmaceutical efforts have been successful in developing COVID-19 vaccines, which have the potential to tackle the socioeconomic burdens of PHSMs and control COVID-19 in the long term (Ashmawy et al. 2022; Ghazy et al. 2022b). However, the development of the vaccine was

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not without challenges. It required complete identification of severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) virology, virulence factors, and variants of concern. Additionally, clinical investigations were necessary to assess the safety, immunogenicity, effectiveness, and efficacy of vaccines. Furthermore, logistic capacities for manufacturing, storage, marketing, and distribution had to be established (Ghazy et al. 2022b; Mendiola-Pastrana et al. 2022; Prachar et al. 2020). On May 22, 2023, it was estimated that approximately 13.36 billion COVID-19 vaccination doses were administered worldwide (World Health Organization 2023b). Libya began the COVID-19 immunization program on April 11, 2021. Up until January 28, 2023, ten types of vaccines were utilized. Libya showed a low coverage rate of ~3.74 million vaccination doses; 54.42 doses were administered/per 100 population, ~33.71% received at least one dose of vaccination, 17.99% were fully vaccinated, and 2.72% had received booster doses. These statistics underscore the status as one of the countries with a less promising vaccination model, along with Yemen, Syria, Iraq, Afghanistan, and Sudan (World Health Organization 2023a).

The well-established availability of COVID-19 vaccines is determined to achieve the purposeful strategy of a "fully vaccinated community in parallel with natural herd immunity" under multifactorial risk factors against COVID-19 vaccination, including inequity and vaccine hesitancy. Vaccine inequity means prioritization by age, serological status, risk exposures, and occupation (Wouters et al. 2021). The WHO defines vaccination hesitancy as "the reluctance or refusal to vaccinate despite the availability of vaccines." The WHO considered vaccine hesitancy to be one of the ten threats to global health in 2019 (World Health Organization 2022). Vaccine hesitancy is a complicated phenomenon that varies between ethnic and racial groups, geographical locations, political affiliations, and a variety of other demographic and cultural variables (Ruiz and Bell 2021). Based on modeling study findings, up to 45 fatalities per million people might be avoided for every one percent reduction in vaccination hesitancy (de Miguel-Arribas et al. 2022).

Unlike existing tools that implement only the 3C model (confidence, complacency, and constraints), the 5C scale has been developed to increase the effectiveness of measures by evaluating five psychological antecedents that influence an individual's vaccination decision. These include confidence in efficacy and safety, complacency toward the essential risk factors, constraints related to logistic capacity, calculation of available medical information, and collective responsibility for public health (Betsch et al. 2020). The 5C has already been used extensively to measure vaccine hesitancy against seasonal vaccine (Sallam et al. 2022), COVID–19 (Abdou et al. 2021), and monkeypox (Ghazy et al. 2022c, 2023b). The purpose of this study was to describe the current situation of COVID-19 vaccination among the Libyan population and predict their position toward vaccination using the 5C scale. By identifying the psychological antecedents that may affect the Libyan population's COVID-19 uptake, this study aims to provide a strategy to increase the vaccination rate in Libya and other countries.

Materials and methods

Study design

To evaluate the psychological antecedents toward COVID-19 vaccination among the Libyan population, an anonymous online cross-sectional survey was conducted from September 1 to October 14, 2022. Study participants were recruited using convenience and snowball sampling techniques, and the questionnaire was distributed on various social media platforms such as Facebook, Twitter, LinkedIn, and WhatsApp.

Sample size and study population

According to the World Bank Statistics, the total population of Libya is 6.7 million, men represent 50.9%, and 95.0% are aged below 65 years (World Bank 2023). To achieve a 95% confidence interval with a 3% margin of error and a response rate of 60%, the minimum required sample size in Libya, where vaccine acceptance was 45% (Elhadi et al. 2021), is 1761 people. This was calculated using the following equation:

$$(\mathrm{N}) = \left(\left(Z^2 \times \mathrm{P} \times (1-\mathrm{P})\right)/(\mathrm{E})^{\hat{}2}\right)/\text{expected response rate}$$:

Where:

(Z) represents the standard normal distribution, which is 1.96 for a 95% confidence interval.

(P) represents the proportion, which is 0.45 for vaccine acceptance in Libya.

(E) represents the margin of error, which is 0.03.

The expected response rate is 60%.
Thus, the calculated sample size (N) is:

$$(\mathrm{N}) = \left(1.96^{\hat{}2} * 0.55 * 0.45\right)/\left(0.03^{\hat{}2}/0.6\right)$$

In this study, we included the adult Libyan population aged 18 years or above who had access to the internet through a smart mobile phone or computer. We excluded those who did not provide informed consent and individuals of other nationalities residing in Libya.

The data collection tool

The questionnaire used in this study was designed using a Google form and was directly linked to an Excel sheet to facilitate data transfer and analysis. The questionnaire consisted of three sections. The first section collected socioeconomic data, including age, sex, education, marital status, and employment status. It also included medical history and information about the participants' previous exposure to COVID-19, such as previous COVID-19 infections, and COVID-19-related deaths among relatives. The second section evaluated the participants' intentions and actual attitudes toward receiving the COVID-19 vaccines. Participants were asked to choose from the following options: "I have already taken the first, second, and booster doses," "I have waited for the booster dose," "I have waited for the second dose," "I would not take the booster dose," "I have taken the first dose but will not take any other doses," and "I will not take any doses." The third and final section of the questionnaire included the validated Arabic and English versions of the 5C scale, which measures vaccine hesitancy based on five domains: confidence, complacency, constraints, calculation, and collective responsibility (Abd ElHafeez et al. 2021; Betsch et al. 2018). The 5C scale used in this study consisted of 15 questions that were evenly distributed across five domains: collective responsibility (Q13–Q15), calculation (Q10–Q12), constraints (Q7–Q9), complacency (Q4–Q6), and confidence (Q1–Q3) (Abd ElHafeez et al. 2021; Betsch et al. 2018). Each question was presented with a seven-point Likert scale, ranging from "extremely agree" to "extremely disagree." The participants were instructed to score each question from 1 to 7. The scores for the three questions in each domain were then summed to produce a total score for that domain. These scores were then dichotomized into "yes" or "no" categories based on predefined cutoff values for each domain. The cut-off values used were as follows: confidence (<5.6 vs. ≥ 5.6), complacency (<4.7 vs. ≥ 4.7), constraints (<6.0 vs. ≥ 6.0), the calculation (<6.3 vs. ≥ 6.3), and collective responsibility (<6.2 vs. ≥ 6.2) (Ghazy et al. 2021). Prior to the actual data collection, a pilot study was conducted by the research team to assess the practicality and accessibility of the online questionnaire. Each team member was asked to send the questionnaire to at least five people to determine the time required to complete the survey and evaluate the feasibility of the study. Based on the results of the pilot study, it was found that the questionnaire could be completed in 5–12 minutes. Additionally, some sentences required minor wording to improve comprehensibility. It was ensured that participants could only submit one response to prevent duplicate submissions.

Operational definitions

Confidence refers to the level of trust that individuals have in the effectiveness of vaccines, as well as trust in the healthcare system and healthcare workers. Low uptake of vaccines, decreased trust in the healthcare system, and increased exposure to disinformation are all consequences of low confidence and distrust in vaccines (Hatmal et al. 2022). The term "constraint" refers to the structural and psychological barriers that can prevent individuals from being vaccinated, even if they are willing to do so. Examples of such barriers include limited access to vaccines, lack of time, low self-efficacy, lack of empowerment, and lack of behavioral control (Betsch et al. 2020). Complacency occurs when individuals perceive the risks of vaccine-preventable illnesses as low and do not consider vaccination to be an essential preventive measure (Khaity et al. 2022). Calculation refers to the process of gathering information to evaluate the risks of diseases versus the benefits of vaccination and make an informed decision. However, relying too heavily on calculation can indicate risk aversion and may negatively impact vaccination behavior (Betsch et al. 2020). Collective responsibility refers to the willingness of individuals to protect others by getting vaccinated, with the ultimate goal of achieving herd immunity and limiting the transmission of the disease. This involves vaccinating oneself not only for personal protection but also to benefit the community as a whole (Abdou et al. 2021).

Study outcome assessment

The primary goal of this study was to evaluate the rate at which COVID-19 vaccination is being rejected among the Libyan population, along with identifying the factors that influence this rejection, including the psychological antecedents, using the 5C scale.

Ethical approval

The study received approval from the Faculty of Medicine, Alexandria University, Alexandria, Egypt (IRB No. 00012098/FWA No. 00018699). Ethical consent was obtained and presented as an initial requirement in the questionnaire. Participants had the option to either provide their consent and complete the questionnaire or decline to participate. All personal information from the participants was treated strictly confidential and kept anonymous throughout the study.

Statistical analysis

Statistical analysis was performed by using the R software version 4.1.1. Categorical variables were reported as counts

and percentages. To compare two independent categorical variables, Pearson's chi-square and Fischer's exact test were used. Furthermore, univariate and multivariate logistic regression models were used to determine the covariates that could influence the rejection of the COVID-19 vaccines. The multivariate model was constructed by including all significant potential predictors of COVID-19 vaccination status that were defined in the bivariate analysis, which included age, sex, occupation, chronic diseases, and 5Cs. The goodness of fit was assessed by checking several assumptions. First, the Hosmer–Lemeshow test showed a *P*-value of 0.58, indicating no difference between observed and expected variance. Second, the chi-square test was used to compare the null model without the addition of any predictors and the full model after adding the covariates, the *P*-value for this test was <0.001, which indicates that the added predictors had significantly changed the model. Third, the variance inflation factor (VIF) was calculated for all the predictors and none of them exceeded the value of 3, which means the absence of multicollinearity between the variables. Finally, the C-statistic was 0.782, indicating the model's high predictive power. A nomogram was used to predict the exact risk of rejecting the vaccine based on the model. Nomograms provide a preliminary visual assessment of different predictors and the rejection of the COVID-19 vaccine. A *P*-value less than 0.05 was considered statistically significant for this analysis.

Results

In the study, a total of 1838 respondents were recruited, of which 97.6% responded to the Arabic version of the questionnaire. Study participants were classified according to their age group, 39.2% belonged to the age group of 25–34 years old, while 34.6% belonged to the age group of 18–24. Additionally, 68.2% of the participants were female, and 59.6% had completed their university education. All participants resided in Libya and held Libyan nationality (99.0%), 50.3% were single, and 23.3% were students. Furthermore, 10.8% of the participants had chronic diseases, while 40.8% had previously contracted COVID-19. Almost half of the respondents (48.6%) had relatives who died from COVID-19. Table 1 provides a detailed overview of the findings.

The study found that vaccine rejection decreased significantly with increasing age, with the highest vaccine hesitancy rates observed among participants aged 18–24 years (76.9%) and 25–34 years (78.6%), and the lowest vaccines hesitancy rates observed among participants aged 35–49 years (66.0%) and those above 50 years (66.0%), with a *P*-value of less than 0.001. Moreover, women were more hesitant about vaccination than men, with a vaccine rejection rate of 76.8% compared to 68.2%, $P < 0.001$. The occupation was also significantly associated with vaccine rejection, with the highest vaccine rejection rate observed among craftsmen and related trade workers (81.1%), with a *P*-value of less than 0.001. Furthermore, we found that the presence of chronic diseases significantly increased vaccine rejection rates among participants, with a vaccine rejection rate of 74.9% compared to 67.3% among those without chronic diseases, with a *P*-value of less than 0.001. However, neither marital status, previous COVID-19 infection, nor deaths among relatives from COVID-19 were found to be significantly associated with attitudes toward vaccination, see Table 2.

The study found that 74.0% of the participants refused COVID-19 vaccination, which means they did not receive vaccination, did not complete the primary vaccination series, or refused booster doses. Specifically, 56.0% of the Libyan population included in the study did not receive any COVID-19 vaccination, while 10.7% did not complete the primary vaccination series, and 7.4% did not receive the booster dose. On the other hand, the overall vaccine acceptance rate (intentional or actual) was 26.0%, with 4.4% of participants receiving the first dose and waiting for the second dose, 17.1% receiving the primary series of vaccination and waiting for the booster, and 4.5% receiving the booster dose Fig. 1.

The 5C scales of the Libyan population

Table 3 shows that 80.0% of the participants expressed confidence in COVID-19 vaccines and in the authorities' making decisions for them, while 91.1% felt complacent about vaccination. However, 78.4% of the participants faced constraints or inconveniences when it came to getting vaccinated. However, 93.9% of the participants made calculations to receive the COVID-19 vaccine, and 93.6% felt a collective responsibility for getting vaccinated, see Table 3.

The study found that, aside from complacency, there was a statistically significant difference between participants who accepted the COVID-19 vaccine and those who did not, in all domains of the 5C model. Specifically, those who accepted the vaccine had a higher level of confidence (95.65% vs. 68.64%, $P < 0.001$), faced fewer constraints (51.39% vs. 80.29%, %, $P < 0.001$), performed more calculations for receiving the vaccine (92.86% vs. 72.83%, $P < 0.001$), and felt a greater collective responsibility (95.73% vs. 72.57%, $P < 0.001$), see Fig. 2.

Several factors were associated with the likelihood of COVID-19 vaccine rejection. Participants aged 50 to 65 years had 69% lower adjusted odds of vaccine rejection compared to those aged 25 years or younger [aOR = 0.31; 95%CI, 0.15–0.62; $P = 0.001$]. Participants aged 35 to 49 years also had 39% lower adjusted odds of rejecting the vaccine compared to those aged 25 years or younger [aOR = 0.61; 95%CI, 0.41–0.89; $P = 0.010$]. Men had 46% lower adjusted odds of vaccine rejection compared to women [aOR

Table 1 Demographic characters of the study participants (n = 1838)

Variable	Demographic characteristics	Total n (%)
Age (years)	18 to less than 24 years	636 (34.6%)
	25 to less than 34 years	720 (39.2%)
	35 to less than 49 years	427 (23.2%)
	50–65 years	55 (3.0%)
Sex	Female	1254 (68.2%)
	Male	584 (31.8%)
Education	Primary education	11 (0.6%)
	Secondary education	417 (22.7%)
	University education	1095 (59.6%)
	Post graduated	315 (17.1%)
Nationality	Egyptian	4 (0.2%)
	Libyian	1820 (99.0%)
	Palestinine	8 (0.4%)
	Sudanese	2 (0.1%)
	Saudi	1 (<0.1%)
	Syrian	3 (0.2%)
Marital status	Single	923 (50.3%)
	Married	850 (46.2%)
	Divorced	65 (3.5%)
Occupation	Student	428 (23.3%)
	Professional job as in the medical field or engineer or chemist	402 (21.9%)
	Clerical support workers	108 (5.9%)
	Craft and related trades workers	159 (8.7%)
	Manager	386 (21.0%)
	Not working/retired	222 (12.0%)
	Others	133 (7.2%)
Have chronic diseases		199 (10.8%)
Have previous COVID-19 infection		749 (40.8%)
Have relatives died from COVID-19		893 (48.6%)

= 0.54; 95%CI, 0.42–0.70; $P < 0.001$]. Craftsmen and trade workers had a significantly (86%) higher adjusted odds of vaccine rejection compared to students [aOR = 1.86; 95%CI, 1.10–3.22; $P = 0.023$]. Participants with chronic diseases had 31% lower crude odds of vaccine rejection compared to those without [cOR = 0.69; 95%CI, 0.51–0.95; $P = 0.023$], although the adjusted odds ratio was not statistically significant. Participants who expressed confidence in the vaccine had (86%) lower adjusted odds of vaccine rejection compared to those without confidence [aOR = 0.14; 95%CI, 0.08–0.23; $P < 0.001$]. There was no significant association between complacency and vaccine rejection [aOR = 1.02, 95%CI, 0.65–1.59, $P = 0.935$]. Participants who faced constraints regarding vaccination had significantly higher adjusted odds of vaccine rejection (4.98 times higher) compared to those without constraints [aOR = 4.98; 95%CI, 3.77–6.60; $P < 0.001$]. Participants who made calculations about taking the COVID-19 vaccine had 79% lower crude odds of vaccine rejection compared to those who did not [cOR = 0.21; 95%CI, 0.09–0.40; $P < 0.001$], although the adjusted odds ratio was not statistically significant. Participants who felt a collective responsibility toward vaccination had significantly lower adjusted odds of vaccine rejection compared to those who did not [aOR = 0.19; 95%CI, 0.06–0.48; $P = 0.001$], see Table 4 and Fig. 3.

Discussion

In a previous publication, we conducted an assessment of the role of psychological antecedents before the vaccine rollout in Libya. The study revealed a strong association between psychological antecedents and the intention to receive the COVID-19 vaccination (Abdou et al. 2021). However, in the current situation where vaccines have already been distributed, Libya is still facing a high rate of vaccine rejection.

Table 2 Socio-demographic and COVID-19 characteristics across vaccination status (n = 1838)

Variable	Demographic characteristics	Total	Accept vaccination n (%)		Reject vaccination n (%)		*p*
		n (%)	n	%	n	%	
Age (years)	18 to less than 25 years	636 (34.6%)	147	23.1	489	76.9	**<0.001**
	25 to less than 35 years	720 (39.2%)	154	21.4	566	78.6	
	35 to less than 50 years	427 (23.2%)	145	34.0	282	66.0	
	50–65 years	55 (3.0%)	31	56.4	24	43.6	
Sex	Female	1254 (68.2%)	291	23.2	963	76.8	**<0.001**
	Male	584 (31.8%)	186	31.8	398	68.2	
Occupation	Student	428 (23.3%)	107	25.0	321	75.0	**<0.001**
	Professional job as in the medical field or engineer or chemist	402 (21.9%)	138	34.3	264	65.7	
	Clerical support workers	108 (5.9%)	37	34.3	71	65.7	
	Craft and related trades workers	159 (8.7%)	30	18.9	129	81.1	
	Manager	386 (21.0%)	104	26.9	282	73.1	
	Not working/retired	222 (12.0%)	34	15.3	188	84.7	
	Others	133 (7.2%)	27	20.3	106	79.7	
Have chronic diseases	Yes	199 (10.8%)	65	32.7	134	67.3	**0.022**
	No	1639 (89.2%)	412	25.1	1227	74.9	
Have previous COVID-19 infection	Yes	749 (40.8%)	200	26.7	549	73.3	0.543
	No	1089 (59.2%)	277	25.4	812	74.6	
Have relatives died from COVID-19	Yes	893 (48.6%)	234	26.2	659	73.8	0.811
	No	945 (51.4)	243	25.7	702	74.3	

Bold indicates significant finding

Therefore, the objective of this study was to examine the association between psychological antecedents and the uptake of COVID-19 vaccines. In this study, we employed the domains of the 5C scale as predictors to assess the Libyan population's position regarding the COVID-19 vaccine. The findings of this study indicated that a significant portion of the Libyan population either did not express an intention to get vaccinated against COVID-19 or outright refused to complete the vaccination schedule. Our study identified several key predictors associated with vaccine rejection among the Libyan population. These predictors included male gender, older age, low confidence in the vaccine, constraints related to vaccination, and a lack of collective responsibility. Indeed, vaccine rejection and hesitancy continue to be significant challenges in the EMR, particularly in countries with low vaccination coverage such as Libya, Sudan, Iraq, Yemen, and Syria. Numerous studies have documented high rates of vaccine hesitancy within the region, which includes hesitancy toward the initial vaccination series (Abdou et al. 2021; Elbarazi et al. 2022; Shaaban et al. 2022) or the booster dose (Abdelmoneim et al. 2022; Ghazy et al. 2022a). This underscores the need for targeted efforts and interventions to address vaccine hesitancy and rejection and promote vaccination acceptance in the EMR countries.

Determinants of vaccine rejection

Socio–demographic criteria: Gender and age have been subjects of extensive study as predictors of COVID-19 vaccine rejection (Abdou et al. 2021; Ghazy et al. 2022a). The findings of this study align with previous research, showing that women and younger individuals under 24 were more likely to refuse vaccination compared to men and older age groups. Additionally, the occupation of individuals has been found to have a significant impact on participants' attitudes toward vaccination. Indeed, occupation can influence factors such as access to information, exposure to healthcare settings, and perceptions of vaccine efficacy and safety. Likewise, in a large study conducted across EMR, we found that women and youth were more hesitant about vaccination in bivariate analysis (Ghazy et al. 2022a). This may be due to their low perceived risk and severity of COVID-19 or fear of the vaccine, especially among women.

Psychological antecedents: In the bivariate analysis, we found that four components of the 5C model, namely confidence, calculation, constraints, and collective responsibility were significantly associated with COVID-19 vaccination uptake. However, in the multivariate analysis, after controlling for other covariates, we identified that confidence,

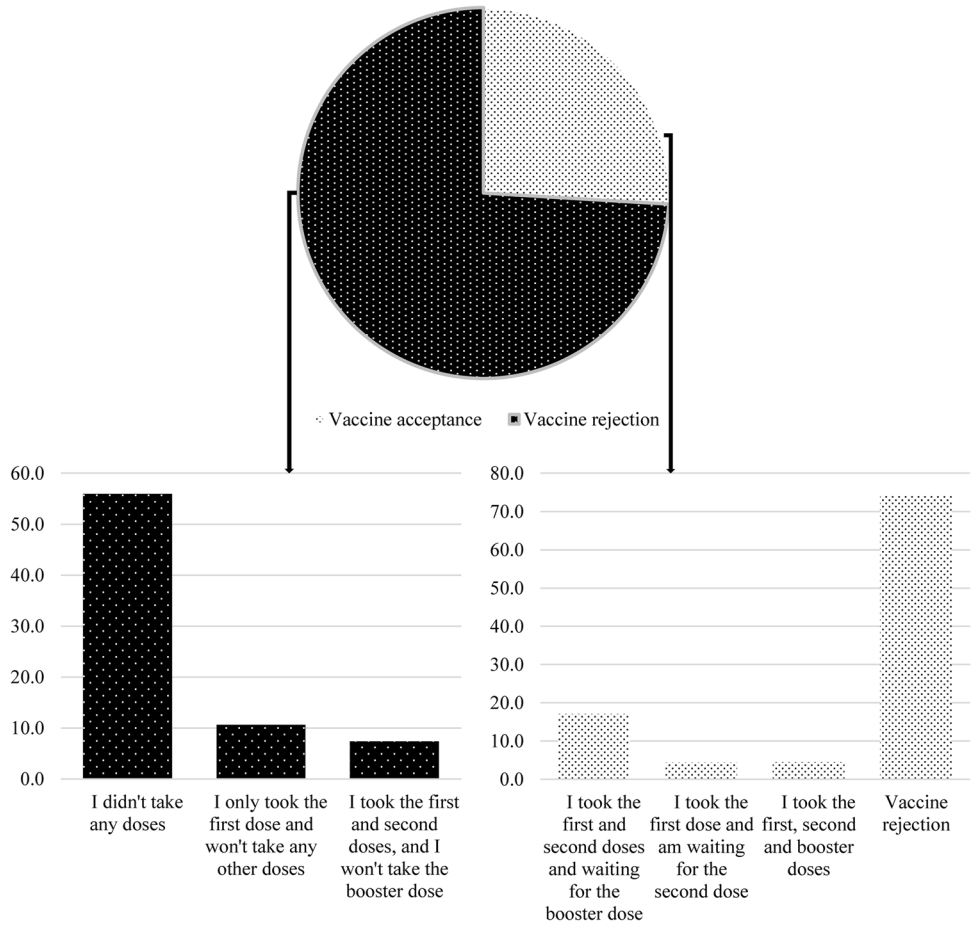

Fig. 1 Attitude toward COVID-19 vaccination among the Libyan population

Table 3 The domains of the 5C scales of the Libyan population overall and across the vaccination status (n = 1838)

5C domain	The 5Cs distributed by vaccination status	Total n (%)
Confidence	No	368 (20.0)
	Yes	1470 (80.0)
Complacency	No	164 (8.9)
	Yes	1674 (91.1)
Constrains	No	397 (21.6)
	Yes	1441 (78.4)
Calculation	No	112 (6.1)
	Yes	1726 (93.9)
Collective responsibility	No	117 (6.4)
	Yes	1721 (93.6)

collective responsibility, and constraints remained the most closely associated factors with COVID-19 vaccination. These findings suggest that initiatives and interventions aimed at improving vaccination intention among the Libyan population would be most effective if they specifically target increasing confidence in the vaccine, fostering collective responsibility, and addressing or reducing the constraints that individuals may face in accessing and receiving the COVID-19 vaccines. In the same vein, in a study conducted by (Wismans et al. 2021), data on COVID-19 vaccination intention among university students from the Netherlands, Belgium, and Portugal was investigated. The researchers used the 5C model as a mediator to examine the psychological determinants of vaccination intention. The results of the study showed that students' COVID-19 vaccination intention was most strongly associated with two components of the 5C model: "confidence" and "collective responsibility." Similarly, in a study conducted by (Machida et al. 2021), in Japan, an internet-based survey was carried out from January 2021 to April 2021, both before and after the delivery of COVID-19 vaccines. The primary objective of the study was to examine the trends in COVID-19 vaccination intention and explore the relationship between the 5C psychological antecedents and vaccination intent. A total of 2655 participants were recruited using quota sampling. The findings of the study indicated that COVID-19 vaccination intention was positively associated with two components of the 5C model: confidence and collective responsibility. On the other hand, the study found a negative association between vaccination

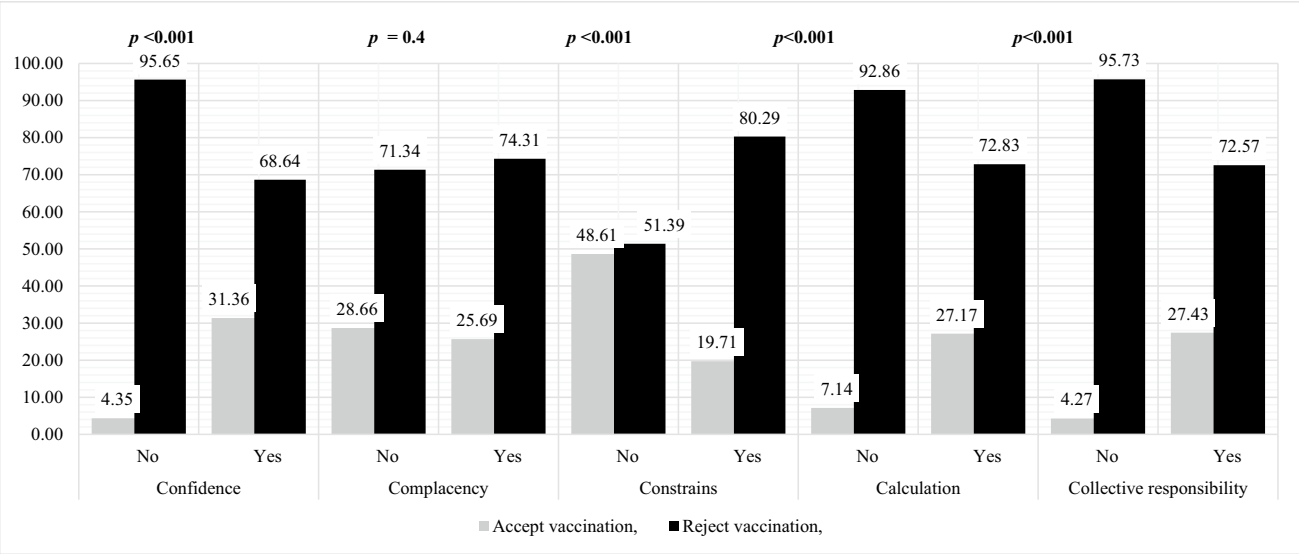

Fig. 2 The 5C scale across Libyan participants based on their attitude toward vaccination

Table 4 Univariate and multivariate logistic regression table showing the predictors of COVID-19 vaccine rejection (n = 1838)

Dependent: COVID-19 vaccination rejection		Crude OR	Adjusted OR
Age (years)	18 to less than 25 years	r	r
	25 to less than 35 years	1.10 (0.85–1.43, $P = 0.446$)	1.10 (0.78–1.54, $P = 0.597$)
	35 to less than 50 years	0.58 (0.45–0.77, $P < 0.001$)	0.61 (0.41–0.89, $P = 0.010$)
	50–65 years	0.23 (0.13–0.41, $P < 0.001$)	0.31 (0.15–0.62, $P = 0.001$)
Sex	Female	r	r
	Male	0.65 (0.52–0.80, $P < 0.001$)	0.54 (0.42–0.70, $P < 0.001$)
Occupation	Students	r	r
	Professionals	0.64 (0.47–0.86, $P = 0.003$)	0.74 (0.49–1.11, $P = 0.150$)
	Clerical workers	0.64 (0.41–1.01, $P = 0.054$)	0.72 (0.41–1.27, $P = 0.252$)
	Craft workers	1.43 (0.92–2.29, $P = 0.120$)	1.86 (1.10–3.22, $P = 0.023$)
	Managers	0.90 (0.66–1.24, $P = 0.528$)	1.06 (0.69–1.64, $P = 0.790$)
	Not working	1.84 (1.22–2.85, $P = 0.005$)	1.58 (0.95–2.67, $P = 0.082$)
	Others	1.31 (0.82–2.14, $P = 0.268$)	1.55 (0.88–2.77, $P = 0.135$)
Chronic diseases	No	r	r
	Yes	0.69 (0.51–0.95, $P = 0.023$)	0.78 (0.54–1.14, $P = 0.197$)
Confidence	No	r	r
	Yes	0.10 (0.06–0.16, $P < 0.001$)	0.14 (0.08–0.23, $P < 0.001$)
Complacency	No	r	r
	Yes	1.16 (0.81–1.65, $P = 0.408$)	1.02 (0.65–1.59, $P = 0.935$)
Constrains	No	r	r
	Yes	3.85 (3.05–4.88, $P < 0.001$)	4.98 (3.77–6.60, $P < 0.001$)
Calculation	No	r	r
	Yes	0.21 (0.09–0.40, $P < 0.001$)	0.44 (0.17–1.01, $P = 0.066$)
Collective responability	No	r	r
	Yes	0.12 (0.04–0.26, $P < 0.001$)	0.19 (0.06–0.48, $P = 0.001$)

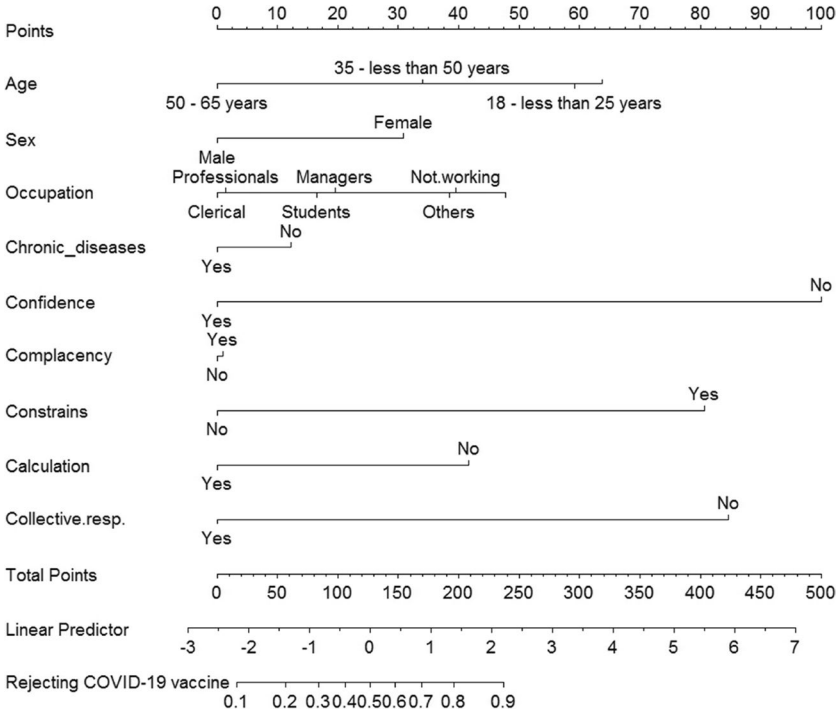

Fig. 3 Nomogram based on the multivariate logistic regression model findings

intention and the calculation component of the 5C model. The study conducted by (Hossain et al. 2021) further contributes to our understanding of the impact of psychological determinants on individuals' attitudes toward vaccination. The researchers collected data from a nationally representative sample of 1497 respondents in Bangladesh, utilizing a combination of online and face-to-face interviews. The results of the study revealed that higher levels of confidence and collective responsibility were associated with a lower hesitancy toward the COVID-19 vaccine. On the other hand, increased complacency and calculation were found to be significant factors contributing to vaccine hesitancy.

The present research highlights the significant role of confidence in vaccination as a key predictor of vaccine rejection. The study found that individuals' perceived threat of COVID-19 and their belief in the effectiveness of the vaccine strongly influenced their decision to get vaccinated. This suggests that individuals who had higher levels of confidence in the government and health authorities were more likely to accept the vaccine and vice versa. These findings align with previous studies conducted by (Ghazy et al. 2021; Machida et al. 2021) which also demonstrated the positive impact of vaccine confidence on vaccine acceptance. That is why it is very important to build and strengthen trust in the government, health authorities, and the vaccine itself for reshaping individuals' attitudes toward vaccination. Combining the COVID-19 vaccine with other vaccines that have already been established as safe and effective could be a promising strategy to reduce COVID-19 vaccine rejection. This approach has been tested in Libya and has shown success in improving vaccine acceptance rates. By leveraging the trust and confidence already established in other vaccines, individuals may be more willing to receive the COVID-19 vaccine as part of a combined immunization effort (Ghazy et al. 2023a). It is worth noting that trust in the vaccine was associated with parents' acceptance of vaccination as well. Elsayed and her colleagues reported confidence in COVID-19 vaccination was predictably related to the intention to vaccinate children. Parents who trusted the vaccine had higher intentions to vaccinate their children (ElSayed et al. 2022). Misinformation, conspiracy ideas, and superstitions about the COVID-19 vaccination and its possible health risks have been proven to erode public faith (Elbarazi et al. 2022; Shaaban et al. 2022). Therefore, these risks and benefits of vaccination should be addressed through effective communication using the commonly used communication channels.

The desire to protect others by getting vaccinated is a strong motivating factor. Our study showed that when participants perceived the risk of COVID-19 for people in their social circle, it indirectly influenced their intention to get vaccinated through a sense of collective responsibility. Indeed, to increase vaccine acceptance, it is important to demonstrate the risks faced by those close to individuals. Vaccination plays a crucial role in achieving herd immunity, which is the indirect protection of unvaccinated individuals through achieving a high vaccination rate in the population. This concept has been experimentally demonstrated in studies such as the one conducted by (Betsch et al. 2020). Therefore, vaccination strategies highlighting the value of vaccination in

terms of protecting others and achieving herd immunity may be more effective. When individuals understand that their decision to get vaccinated not only protects themselves but also contributes to the well-being of their loved ones and the public, they are more likely to prioritize vaccination.

In multivariate logistic regression analyses, we identified constraints as a significant factor associated with COVID-19 vaccination. It is important to note that the cost of vaccination was not considered a constraint in our study, as the vaccines were administered free of charge. Perceived constraints can arise from various factors such as limited access to vaccination services, ineffective service delivery, or hesitancy among certain minority groups to register for vaccination. These constraints can hinder individuals from receiving the vaccine, even when it is readily available. To address these constraints, it may be necessary to implement strategies that enhance the accessibility of immunization services. Outreach vaccination campaigns, such as ring vaccination, can be effective in reaching individuals who face barriers to accessing traditional vaccination sites. By bringing vaccination services directly to communities, we can overcome geographical and logistical challenges that may limit vaccine uptake. Additionally, further research is needed to gain a deeper understanding of the specific constraints faced by the Libyan population in relation to COVID-19 vaccination. This can help inform targeted interventions and policies aimed at addressing these constraints and improving vaccine acceptance.

Limitations and strengths

It is important to acknowledge several limitations of our study. First, we did not employ a probabilistic sample, which may limit the generalizability of our findings to the wider population. Second, data collection was conducted online through the distribution of the questionnaire on social media platforms. While this method allowed for convenient data collection, it may introduce sampling bias as not all individuals have equal access to the internet or engage with social media. This could impact the representativeness of our sample and potentially limit the external validity of our findings as well. However, according to a recent report by Digital Report approximately 3.5 million Libyans use the Internet and almost 91.0% of Libyans are using social media (Kemp 2022). Furthermore, the data collected for this study pertained to a specific point in time (September and October 2022). Given the dynamic nature of the COVID-19 pandemic and evolving public perceptions and attitudes toward vaccination, the positions of the population may have changed over time. Despite these limitations, our study has several strengths. First, we utilized a large sample size and employed a comprehensive sampling procedure to include diverse public sectors, which enhances the representativeness of our study to a certain extent. Additionally, we applied the 5C domains in a novel context by using them to predict the positions of respondents toward COVID-19 vaccination. This expands the utility of the 5C model beyond its original intention of predicting vaccination intentions. Moreover, instead of solely focusing on vaccine intention, we examined actual and intentional vaccination behavior. This provides valuable insights into the factors influencing the actual uptake of COVID-19 vaccines among the Libyan population.

Conclusions

This study provides valuable insights into the factors influencing the position of the Libyan population toward COVID-19 vaccination. The findings can be used to guide governments and public health managers in developing targeted interventions and strategies to reduce vaccine rejection. It is worth noting that a considerable proportion of the studied population did not receive or complete their vaccination schedule. The 5C scale proved useful in predicting individuals' attitudes toward COVID-19 vaccination. While non-modifiable factors such as age and sex influence vaccine rejection, psychological antecedents like confidence, constraints, and collective responsibility had a more substantial impact that can be addressed and modified through targeted interventions.

List of abbreviations *COVID-19*: Coronavirus disease 2019; *EMR*: East Mediterranean Region; *WHO*: World Health Organization; *aOR*: Adjusted odds ratio; *cOR*: Crude odds ratio; *SARS-CoV-2*: Severe acute respiratory syndrome coronavirus 2

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Declarations

Ethical approval The study received approval from the Faculty of Medicine, Alexandria University, Alexandria, Egypt (IRB No. 00012098/FWA No. 00018699). Ethical consent was obtained and presented as an initial requirement in the questionnaire.

Conflict of interest The authors declare that they have no conflicts of interest related to this research study.

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