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Original Research

Shaping North-African Public Health Decisions: A Latent Class Analysis of Social Media's Influence on Attitudes and Behaviors Towards COVID-19 Vaccines

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Background: The global crisis brought on by the COVID-19 pandemic highlighted the crucial role of vaccines in public health. However, the success of vaccination campaigns is not solely determined by the availability of vaccines but also by public willingness to receive them. In North Africa, the variability in vaccine acceptance has raised concerns, drawing attention to the need for understanding the factors influencing public attitudes.

Objectives: To identify the impact of the information consumption modalities related to the Coronavirus Disease 2019 (COVID-19) pandemic and its vaccines, on the vaccine uptake decision among social media users. Also, to study the relationships between vaccination attitudes, and latent subgroups, in terms of socio-demographic variables, fear of COVID-19 and perceived stress.

Method: A total of 723 subjects (males: 48.8%; mean±standard deviation of age: 31±11 years), participated in our survey prepared online on the Google Forms application via the platforms Twitter and Facebook.

Results: Five latent classes were identified by the analysis: *Class 1* (mixed consumers), *class 2* (largest consumers of social media), *class 3* (consumers of official information), *class 4* (low consumers of information on the vaccine), and *class 5* (social media consumers and information verifiers). The subgroup that is knowledgeable about COVID-19 pandemic and its vaccines, and which consumes the most information about the vaccine from official sources, is the one with the highest vaccine acceptance rate. In addition, the hesitant attitude towards the COVID-19 vaccine was linked to gender and mask wearing, while refusal behavior was linked to age, female gender, education level, mask wearing, and fear of COVID-19.

Conclusion: This study's investigation into the impact of social media on public attitudes and behaviors towards COVID-19 vaccines in North Africa has significant implications for both public health strategy and policy. By identifying distinct latent classes based on social media usage patterns, the research reveals a complex landscape of factors influencing vaccine hesitancy in the region. The nuanced understanding derived from these findings is crucial for the development of more effective public health messaging, tailored to address the specific concerns and misinformation trends prevalent within each identified group. The insights gained from this study can guide policymakers in allocating resources more effectively, particularly in areas exhibiting higher levels of vaccine hesitancy.

Keywords: *Behavioral analysis, Digital influence, Health decision-making, Public opinion, Vaccination attitudes.*

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INTRODUCTION

The Coronavirus Disease 2019 (COVID-19) pandemic has been characterized by the rise of social media as a primary source of disinformation and conspiracy about the disease [1, 2]. In fact, Krause et al. [3]coined the term "misinfodemic" to capture the corresponding increase in misinformation surrounding the virus. Indeed, a significant proliferation of false, fictitious and inaccurate information and conspiracy theories were disseminated through social platforms and consumed by users who wanted to have information about the disease [4]. This has hampered the efforts of scientists, medical professsionals and governments to communicate effectively about the virus. The stress and anxiety triggered by the pandemic can lead to overuse the internet for information and comfort, exacerbating social isolation issues [5, 6]. As vaccination decisions are influenced not only by health considerations but also by psychological factors such as trust, perceived risks and online information [7] problematic internet use potentially contributes to the spread of misinformation and affects vaccine perceptions [8]. Addressing mental health concerns and mitigating internet-related issues are critical to promoting honest decision-making about vaccination and increasing trust in vaccination initiatives [9]. A plethora of vaccine-related misinformation was shared on social media even before vaccines became available [10-12], thus posing a serious threat to public health, and economic stability. In particular, Horton [13] has pointed out a high consumption of unreliable information for subgroups who had limited knowledge about health or other groups who were not able to assess the credibility of information [14]. Indeed, several negative thoughts and conspiracy theories regarding COVID-19 vaccines have been reported in several studies. For instance, Sallam et al. [15]found that 27.7% believed that COVID-19 vaccines were intended to inject microchips and 23.4% of study participants believed vaccines were made to decrease fertility.

Given that the many facets of fake news and disinformation are difficult to explain and properly disentangle [16], they can be viewed in such circumstances as a source of very high risk, which complicates the public's perception of the initial risk. In general, false, misleading or inaccurate health information can pose a serious risk to public health and to the implementation of public policies [17]. In addition, the risk of misinformation about COVID-19 vaccines interacts with the risks of the pandemic itself, creating risk on many levels if people refuse to be vaccinated.

Based on the critical role of social media in information dissemination during the COVID-19 pandemic and its potential impact on public health decisions, our study aimed to identify the impact of the information consumption modalities related to the COVID-19 pandemic and its vaccines on the vaccination decision among social media users. Also, we aimed to study the relationships between vaccination behav1iors/attitudes, and latent classes/subgroups, in terms of socio-demographic and psychological (fear of COVID-19 and perceived stress) variables.

METHODS

Ethical Considerations The protocol of the present study has received the ethical authorization of the United Nations Educational, Scientific and Cultural Organization (UNESCO) Chair, Health Anthropology Biosphere and Healing Systems, University of Genoa, Genoa (Italy), the Higher Institute of Sport and Physical Education of Sfax, Sfax (Tunisia), the Faculty of Letters and Human Sciences of Sfax, Sfax (Tunisia), and the Higher Institute of Sport and Physical Education of Kef, Kef (Tunisia).

Subjects were well informed about the objectives of the study, clearly stated in the introductory part of the survey, and were told that anonymity would have been guaranteed. The study is in line with the ethical principles of the 1964 Helsinki Declaration and its subsequent amendments [18].

Data Collection and Procedures

"In July 2021, data was gathered in Tunisia through an online survey distributed on social media platforms, specifically Twitter and Facebook, utilizing the Google Forms application. The survey had 723 participants, all of whom were Arabic native speakers and Muslims. During that period, Tunisia reported 497,613 confirmed COVID-19 cases and 144 deaths."

The recruited subjects have been analyzed based on their distribution by gender, by age, and by educational status (higher and secondary education levels). The characteristics of the study participants are detailed in Table 1.

Instruments

A three-section questionnaire was developed to collect the data. The first section contains the following socio-demographic variables: age, gender, religion, native language spoken, education level, and marital status (single/married). In addition, this section asked the participants about the history of COVID-19 (test positive/test negative/no test performed) and the wearing of a mask (always/sometimes/never). The second section presents questions related to the decision to be vaccinated against COVID-19, the consumption of information on social media about the disease and its vaccines, and also, it asks them about their knowledge in terms of COVID-19 and its vaccines. We detail below the questions and the proposed answers. In this Latent Class Analysis (LCA), the latent variable represents categories of underlying risk that may lead to hesitancy towards the COVID-19 vaccination. We used a total of 13 items which are as follows:

1. Do you have a lot of knowledge about COVID-19? (COVID-19 knowledge)
2. Do you have a lot of knowledge about the COVID-19 vaccine? (Vaccine knowledge)
3. Do you consume information about COVID-19 vaccine disseminated by official sources? (Official vaccine news consumption)
4. Do you have confidence in the information related to COVID-19 vaccine disseminated by official sources? (Official vaccine news confidence)
5. Do you share information related to COVID-19 vaccine that is disseminated by official sources? (Official vaccine news sharing)
6. Do you consume information on social media? (Social Media news consumption)
7. Do you have confidence in the information disseminated in social media? (Social Media news confidence)
8. Do you share information on Social Media? (Social Media vaccine news sharing)
9. Do you consume information related to the COVID-19 vaccine on social media? (Social Media vaccine news consumption)
10. Do you have confidence in the information related to the COVID-19 vaccine disseminated in social media? (Social Media vaccine news confidence)
11. Do you share information related to the COVID-19 vaccine on social media? (Social Media vaccine news sharing)
12. Do you check the consumed information related to the COVID-19 vaccine? (Social Media news verification)
13. Are you able to detect false information (disinformation) related to the COVID-19 vaccine? (Social Media news Disinformation detection)

The third section contains the items of two validated measurement instruments: the first instrument measures fear of COVID-19 and the second measures perceived stress. The description of the two tools is presented below.

The COVID-19 Fear Scale

The adapted Arabic version of the COVID-19 Fear Scale of Alyami et al. [19] was used in our study. This version has been translated and adapted into Arabic version from the initial one by Ahorsu et al. [31]. The scale assesses fear of COVID-19 by a one-dimensional factor divided into seven items with a 5-point Likert scale. Concomitant and confirmatory reliability and validity were examined on a set of Saudi participants. The internal consistency of the Arabic version examined using Cronbach Alpha was satisfactory ($\alpha = 0.88$), with strong concurrent validity indicated by significant and positive correlations with the Hamilton Hospital Anxiety and Depression Scale (HADS) Anxiety Sub-scale: $r = 0.6$. Likewise, the examination of the factor structure [32] was adequate (Confirmatory Fit Index (CFI) = 0.995; Root Mean Square Error of Approximation (RMSEA) [90% confidence interval (CI)] = 0.059, and Standardized Root Mean Squared Residual (SRMR) = 0.024).

The Perceived Stress Scale (PSS-10)

The Arabic language version of the PSS-10 [20], as adapted by Almadi et al. (2012) [, was used to assess stress. The PSS-10 is divided into two sub-scales, six items measure perceived psychological distress, while the others test the coping strategy. Scores are obtained on a 5-point Likert scale ranging from 0 to 4. The reliability and validity of the PSS-10 in its Arabic version presented a two-factor structure suitable for exploratory factor analysis and the coefficients of Cronbach's alpha were 0.74 and 0.77, respectively. In addition, the test-retest reliability had an intra-correlation coefficient (ICC) of 0.90. For our study considering only the related negative factor, which is distress, the coping strategy will not be taken into consideration.

Statistical tools

The LCA was carried out by means of the "poLCA" package of the R Studio software version 1.4.1103, while descriptive statistics and multinomial logistic regression were conducted by SPSS version 26 software.

A series of preliminary LCA models was performed by the "poLCA" package to identify a model with the optimal number of classes. First, we adapted LCA models with an increasing number of classes without covariates. We reported for each model the recommended model fit indices: the Akaike information criterion (AIC), the Bayesian Information criterion (BIC), the adjusted BIC (aBIC), the log-likelihood, the likelihood-ratio, and the entropy values. Then, we performed a comparison to identify the most suitable model. The BIC is recommended for its dependence on both the log-likelihood and the adjusted sample size [21]. The lower values of BIC indicate a better fit, therefore, a model with the lowest BIC is usually retained for analysis.

Multivariate analysis was performed using multinomial logistic regression to examine the association between psychological status, and a priori selected demographic variables, including age, gender, marital status, years of work, education level, current position, type of job and original position too.

RESULTS

The characteristics of participants who responded to the scales are presented in Table 1. The recruited subjects have been analyzed based on their distribution by gender (females: 370 (51.2%)), by age (mean ± standard deviation of age: 31±11 years), and by educational status (higher level (85.3%), and secondary level 14.7%)). The characteristics of the study participants are detailed in Table 1.

Table 1. Demographic characteristics and students' responses.

	Latent class				
	Class 1	Class 2	Class 3	Class 4	Class 5
n (%)	(15.6%)	(26.1%)	(21.0%)	(23.9%)	(13.3%)
Age Mean	34.30	28.89	34.47	28.43	30.97
SD	11.92	9.18	12.04	9.36	10.25
COVID-19 fear Mean	2.77	2.75	2.77	2.96	2.88
SD	0.90	0.93	0.92	0.92	0.99
Stress Mean	2.13	2.05	2.07	2.23	2.19
SD	1.03	0.89	0.91	0.92	1.00
Yes n	76	14	113	5	20
%	33.3%	6.1%	49.6%	2.2%	8.8%
Vaccine uptake Hesitant/reluctant n	20	116	27	75	39
decision %	7.2%	41.9%	9.7%	27.1%	14.1%
No n	17	59	12	93	37
%	7.8%	27.1%	5.5%	42.7%	17.0%
Male n	66	85	92	70	40
Gender %	18.7%	24.1%	26.1%	19.8%	11.3%
Female n	47	104	60	103	56
%	12.7%	28.1%	16.2%	27.8%	15.1%
High n	99	167	130	136	85
Education level %	16.0%	27.1%	21.1%	22.0%	13.8%
Secondary n	14	22	22	37	11
%	13.2%	20.8%	20.8%	34.9%	10.4%
Single n	70	138	80	137	64
Status %	14.3%	28.2%	16.4%	28.0%	13.1%
Married n	43	51	72	36	32
%	18.4%	21.8%	30.8%	15.4%	13.7%
Test positive n	13	29	17	17	15
%	14.3%	31.9%	18.7%	18.7%	16.5%
COVID-19 Test Test negative n	16	38	20	23	22
%	13.4%	31.9%	16.8%	19.3%	18.5%
Not performed n	84	122	115	133	59

%	16.4%	23.8%	22.4%	25.9%	11.5%
Regular n	78	84	111	60	42
%	20.8%	22.4%	29.6%	16.0%	11.2%
Mask use Occasional n	27	58	36	68	37
%	11.9%	25.7%	15.9%	30.1%	16.4%
Never n	8	47	5	45	17
%	6.6%	38.5%	4.1%	36.9%	13.9%
Yes n	81	23	139	10	7
%	31.2%	8.8%	53.5%	3.8%	2.7%
COVID-19 knowledge Neutral n	9	148	13	88	17
%	3.3%	53.8%	4.7%	32.0%	6.2%
No n	23	18	0	75	72
%	12.2%	9.6%	0.0%	39.9%	38.3%
Yes n	104	31	125	10	0
%	38.5%	11.5%	46.3%	3.7%	0.0%
Vaccine knowledge Neutral n	4	145	27	95	21
%	1.4%	49.7%	9.2%	32.5%	7.2%
No n	5	13	0	68	75
%	3.1%	8.1%	0.0%	42.2%	46.6%
Yes n	95	28	137	15	16
%	32.6%	9.6%	47.1%	5.2%	5.5%
Official vaccine news Neutral n	13	148	15	62	13
Consumption %	5.2%	59.0%	6.0%	24.7%	5.2%
No n	5	13	0	96	67
%	2.8%	7.2%	0.0%	53.0%	37.0%
Official vaccine news Yes n	103	52	134	3	51
Confidence %	30.0%	15.2%	39.1%	0.9%	14.9%
Neutral n	2	117	18	51	8

A series of LCA models specifying latent class numbers from 1 to 10 have been fitted. To decide on the number of latent classes, we evaluated successive models to identify themodel with a combination of the lowest values of the AIC and the BIC and high entropy.

The five-class model was retained after analysis as it presented the best fits with the smallest values of AIC (= 18440.53) and BIC (18306.53). In addition the value of entropy = 0.838 was satisfactory (being greater than the recommended threshold 0.80).

The goodness-of-fit criteria for the sequence of the ten unadjusted models (i.e. no covariates) as a function of the number of identified classes are presented in Table 2.

Five latent classes were identified by the analysis (Figure 1): class 1 (mixed consumers), class 2 (largest consumers of Social Media), class 3 (consumers of official information), class 4 (low consumers of information on the vaccine) and class 5 (Social Media consumer information verifiers).

Table 2. Summary of Latent Class Model Identification and Statistics (N = 723).

Models	Log-likelihood	Residual degrees offreedom	BIC	aBIC	AIC	Likelihood-ratio	Entropy
Model 1	-10025.901	697	20222.97	20140.41	20248.97	10742.112	-
Model 2	-9118.339	670	18585.60	18417.31	18638.60	8926.989	0.925
Model 3	-8964.021	643	18454.71	18200.69	18534.71	8618.352	0.838
Model 4	-8821.448	616	18347.32	18007.56	18454.32	8333.207	0.826
Model 5	-8712.177	589	18306.53	17881.04	18440.53	8114.665	0.838
Model 6	-8636.112	562	18332.15	17820.93	18493.15	7962.536	0.836
Model 7	-8566.653	535	18370.99	17912.95	18558.99	7823.618	0.850
Model 8	-8501.681	508	18418.80	18004.97	18633.80	7693.673	0.869
Model 9	-8441.716	481	18476.62	18096.99	18718.62	7573.743	0.899
Model 10	-8386.218	454	18543.37	18189.01	18812.37	7462.747	0.894

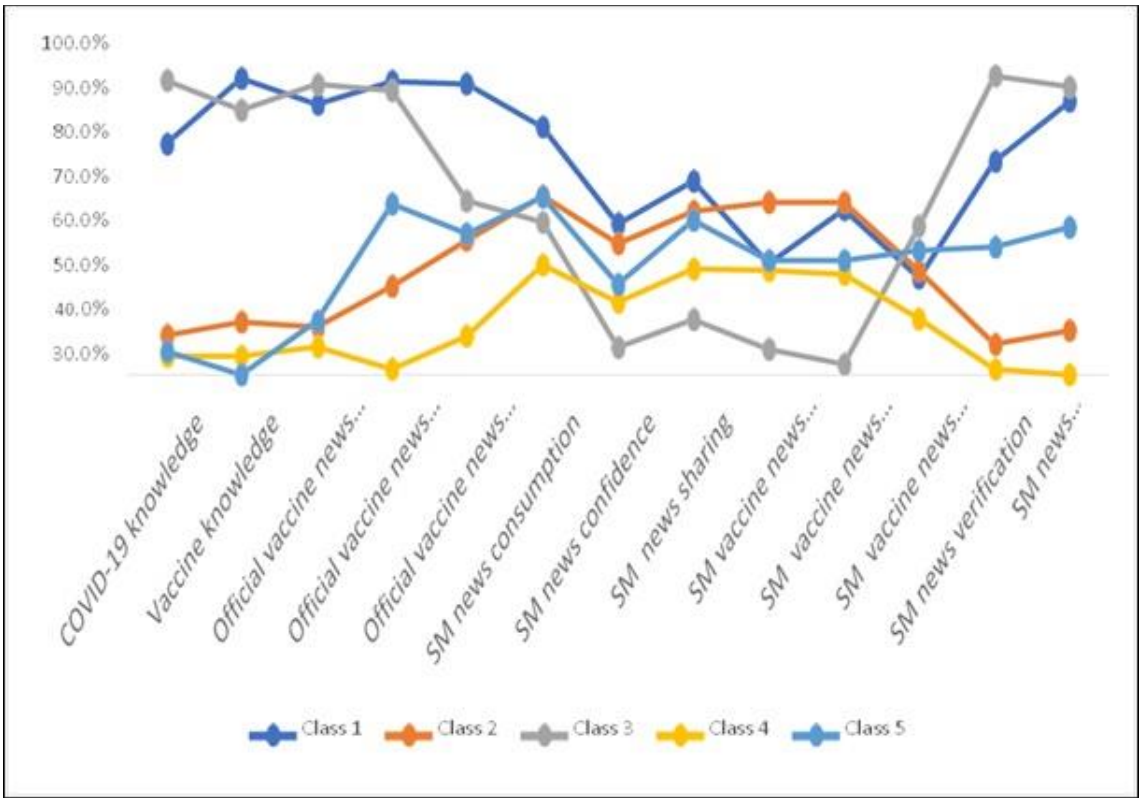

Figure 1. Informational characteristics of latent classes (COVID-19: Coronavirus Disease 2019, Class 1: Mixed consumers, Class 2: The largest consumers of social media, Class 3: Consumers of official information, Class 4: Low consumers of information on the vaccine, Class 5: Social media consumer information verifiers, SM: Social Media).

The two classes (1 and 3), which are consumers of information from official sources, hold the most information on COVID-19 pandemic and its vaccines. Furthermore, these two classes verify the information consumed, and have the ability to distinguish between reliable and false information. For example, class 1 (15.6%), which presents people who consume the most information on COVID-19 and its vaccines from official sources and social media, is characterized by its confidence in the information broadcasted on social media. This class constantly diffuses the information consumed (60.2%), including the information on the COVID-19 vaccines (34.5%).

Class 3 (21%) is formed by participants who mainly consume their information from official sources. Very little information is consumed from social media, which are little or not trusted. This latent class does not participate in the dissemination of information related to COVID-19 and its vaccines on social networks.

The three other classes (2, 4 and 5) do not have enough information about the COVID-19 and its vaccines. The class 2 (26.1%) is mainly made up of people with little knowledge about the COVID-19 and its vaccines. They consume disease and vaccine information primarily from social media. This class trusts this information and shares it without verification; however, they cannot distinguish between false and reliable information about disease and vaccination. We can say that this class is a major contributor to the spread of false information about COVID-19 and its vaccines on social networks.

The class 4 (16.18%) does not use the official information disseminated on COVID-19 and its vaccines, they consume in a moderate way the information shared on social media, which is their main source of information about the disease and the vaccines. Those in this class do not verify the information consumed and do not have the ability to distinguish between accurate information and misinformation about the disease and the vaccine. The behavior of this class on social networks may be amplifying the information of false information.

Class 5 (13.3%) presents people who do not have information about COVID-19 and the vaccines. They

learn about the disease and the vaccines sparingly from official sources and moderately from social media. They verify the information consumed and have the ability to scrutinize the information shared. Consumption, diffusion and verification of information for this class on social networks can be considered as moderate behavior. Subsequently, the vaccination behaviors/attitudes were compared between the classes (Figure 2). Chi square test presented a value of 342.05 ($p < 0.001$). The third class and the first class had the highest percentages of people who accepted the COVID-19 vaccine (67.3% and 74.3%, respectively).

The second class has the highest rate of people who refused to be vaccinated (61.4%), while the highest vaccine refusal rates were in class 4 (53.8%) and class 5 (38.50%), respectively.

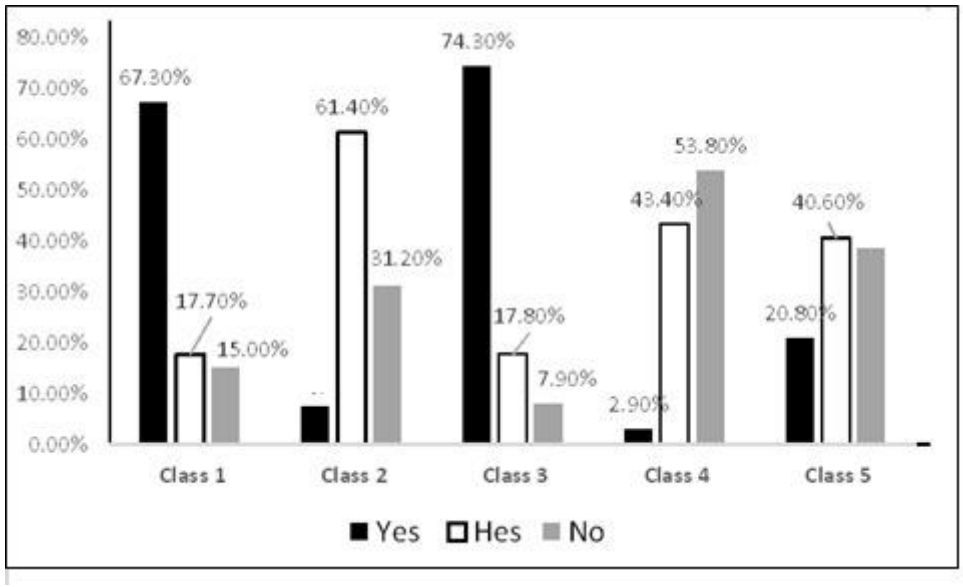

Figure 2. Vaccination behavior among the five latent classes.

Since differences were found between classes on vaccine reluctance, we performed a multiple regression analysis to examine factors that might predict COVID-19 vaccine reluctance (Table 3). In this multinomial regression model, using class 5 as reference class and when compared to its counterparts, the groups with a statistically significant probability of being less reluctant towards vaccine were class 3 and class 1 (Adjusted Odds Ratio), whereas the group with a higher willingness of vaccine hesitancy was class 4, followed by class 2, even if, in this case, the significance threshold could not be achieved. In addition, concerning the socio-demographic variables, increasing age, female gender, and the permanent wearing of the mask were associated with lower levels of vaccine hesitancy.

In terms of predictors of vaccine refusal, belonging to class 4 was statistically significant where class 1 and 3 memberships were associated with significantly low refusal rates. Belonging to class 2 did not achieve significance threshold.

Other variables were also predictors of vaccine refusal, including increasing age, female gender, high educational level, regular mask wearing, and fear of COVID-19.

Table 3. Multinomial logistic regression analysis shedding light on the COVID-19 vaccination attitudes (N = 723).

		B	SE	Wald	AOR (95% CI)
Hesitancy	[Class = 1]	-1.81***	0.40	20.28	0.16 (0.07-0.36)
	[Class = 2]	1.54***	0.42	13.50	4.66 (0.36-10.58)
	[Class = 3]	-1.88***	0.38	24.19	0.15 (0.07-0.32)
	[Class = 4]	2.14***	0.57	14.32	8.52 (2.81-25.86)
	Age	-0.03	0.01	3.72	0.97 (0.94-1.00)
	[Gender = female]	-1.21***	0.25	22.53	0.30 (0.18-0.49)
	[Education = high level]	0.17	0.39	0.18	1.18 (0.55-2.55)
	[Status = single]	0.36	0.33	1.18	1.43 (0.75-2.75)

	[COVID-19 test = positive]	0.16	0.39	0.17	1.18 (0.55-2.53)
	[COVID-19 test = negative]	-0.03	0.34	0.01	0.97 (0.50-1.89)
	[Mask = always/regular use]	-0.94*	0.41	5.26	0.39 (0.17-0.87)
	[Mask = occasional use]	0.14	0.45	0.10	1.15 (0.48-2.76)
	COVID-19 fear	-0.14	0.15	0.84	0.87 (0.65-1.17)
	Stress	0.18	0.14	1.60	1.20 (0.90-1.59)
Refusal	[Class = 1]	-1.93***	0.43	20.02	0.15 (0.06-0.34)
	[Class = 2]	0.83	0.44	3.54	2.30 (0.97-5.47)
	[Class = 3]	-2.74***	0.46	35.89	0.06 (0.03-0.16)
	[Class = 4]	2.29***	0.58	15.84	9.89 (3.20-30.55)
	Age	-0.07***	0.02	16.74	0.93 (0.90-0.96)
	[Gender = female]	-1.36***	0.28	24.52	0.26 (0.15-0.44)
	[Education = high level]	-0.92*	0.39	5.60	0.40 (0.19-0.85)
	[Status = single]	0.10	0.36	0.08	1.11 (0.54-2.26)
	[COVID-19 test = positive]	0.24	0.42	0.33	1.27 (0.56-2.92)
	[COVID-19 test = negative]	-0.24	0.37	0.42	0.79 (0.38-1.62)
	[Mask = always/regular use]	-1.17**	0.44	7.06	0.31 (0.13-0.74)
	[Mask = occasional use]	0.23	0.47	0.24	1.26 (0.50-3.13)
	COVID-19 fear	-0.40*	0.16	6.24	0.67 (0.49-0.92)
	Stress	0.27	0.16	2.94	1.31 (0.96-1.77)

Foot notes: Class 5 is the class reference; male is the gender reference; secondary level is the educational level reference; married is the status reference; not performed is the reference category for the COVID-19 test, and is never is the reference category for the wearing of the mask. AOR: Adjusted Odds Ratio

DISCUSSION

This study helps identify significant subgroups/clusters that have similar behaviors about the misinformation related to COVID-19 and its vaccines and explore the relationship between derived latent subgroups and psychological responses to the pandemic.

These results were able to highlight differences in terms of the COVID-19 vaccination behaviors/attitudes in the different latent classes. Indeed, the class 3, which is knowledge able about the COVID-19 and its vaccines and consumes the most information about the vaccine from official sources, is the class with the highest rate of people who want to be vaccinated. On the other hand, class 2 which trusts social media as the main source of information without scrutinizing them and without having the ability to distinguish between accurate information consumed and misinformation, has one of the lowest rates of people willing to be vaccinated, together with class 4.

Similar results to our study were reported in the investigation of Chadwick et al. [22] on consumer information about the COVID-19 vaccine on a large adult UK sample. The cluster analysis identified six classes: namely, i) news avoiders, ii) consumers of information from public/official sources, iii) super researchers, iv) mixed consumers, v) social media addicts, and vi) TV addicts. The results showed that the super-researcher and mixed media classes were linked to online provaccination behaviors.

In addition, our results showed high rates of hesitancy and refusal of vaccination among study participants, which was demonstrated in several other populations. Also, the results revealed that vaccination behavior is related to an array of variables. For example, for the hesitancy of the COVID-19 vaccine, the results revealed that female gender and mask wearing are significant predictors of vaccine hesitancy, while for vaccine refusal, age, female gender, educational level and fear of COVID-19, were significant predictors. According to the literature, psychological variables such as fear of COVID-19 can intensify feelings about vaccination and lead to hesitancy/refusal phenomena. Indeed, vaccine hesitant/reluctant respondents differed in several studies on a number of sociodemographic and health-related variables but were similar in terms of a wide range of psychological parameters. In line with Murphy et al. [23], people reluctant to the COVID-19 vaccine were less likely to obtain information about the pandemic from traditional sources and had similar levels of distrust towards these sources compared to respondents accepting the vaccine. These results are similar to those of Yin et al. [24] who explored more than 1.75 million messages about COVID-19 vaccines disseminated on the social media platform Weibo (a popular platform in China).

In addition, our gender-related results are confirmed by several studies. As an example, Sallam et al. [15] reported COVID-19 vaccine acceptance rates of nearly 39% and 23.9% for men and women, respectively, among a population recruited from several Arab countries. The authors' explanation of gender differences was the different sources of information between the two genders. Men relied mainly on doc tors, scientists and scientific journals, while women made more use of social media platforms.

In another study that examined the associations between vaccination behavior and socioeconomic variables, Dror et al. [25] found a predictive link between male gender and acceptance of COVID-19 vaccination. In contrast, age was not a key predictor of behavior towards COVID-19 vaccines. In line with our results, recent studies have reported links between the acceptability of the COVID-19 vaccine and several demographic variables that enable to identify distinct subgroups that exhibit specific attitudes. As an example, in the study by Khubchandani et al. [26], vaccination behavior was significantly associated with gender, education, employment and income. Also, Robertson et al. [27] found higher rates of hesitancy among women, younger age groups, and those with lower education levels.

Also, the readiness to immunize differed by stratifying according to age and level of education. Furthermore, in a national study in Poland, Feleszko et al. [28] showed that 28% of adults in Poland were not willing to be vaccinated. Alarmingly, a majority (51%) of reluctant respondents indicated that their opinions would have not been changed by any kind of information regarding the safety and efficacy of vaccines, or whether they would have been threatened with heavy fines if the vaccine would have become compulsory [29].

In addition, a massive amount of misinformation shared on social media can spread from a country to another country in a fluid and permanent manner and without control. Indeed, Wilson and Wiysonge [30] found in a study carried out in 137 countries that the amount of disinformation disseminated predicted the drop-in vaccination rates over time. In conclusion, COVID-19 vaccine-related online behavior is characterized by the interplay of several variables, including ethnicity, age, gender, education level and job status, among others [31], and a better understanding of its determinants can lead to the implementation of adequate public health strategies and policies aimed to increase vaccine uptake.

LIMITATIONS

The main limitations of the study lie mainly in the size of the sample and in the recruitment strategy, which does not make the sample representative of the general population. In addition, the lack of valid and reliable tools to measure vaccination behavior and consumer attitudes online has prompted us to use categorical variables and not measurement scales. Furthermore, an examination of other variables like country region, and health status (underlying disease(s) and co-morbidities, risk factors for COVID-19) or specific populations such as medical staff members and healthcare workers, should be included in future research. Finally, users of other social media platforms (YouTube, Snapchat, TikTok, Reddit, Instagram, Pinterest, WhatsApp, and other social networks) should be investigated as well, even though it should be noted that Facebook is the leading social media platform in Tunisia, being actively used by, approximately, 85% of the country's internet users.

CONCLUSION

The study identified the modalities in which information about the COVID-19 vaccine was consumed. Five latent classes were identified and explored in terms of their vaccination behaviors/attitudes. Acceptance of the vaccination has been linked to the consumption of information from official sources, while higher rates of hesitation and refusal of vaccination have been demonstrated for consumers of information from social media without verification and without the ability to detect misinformation.

In addition, hesitancy/reluctance behaviors were also related to sex and mask wearing, while refusal behavior was related to age, female gender, education level, mask wearing, and fear of COVID- 19.

Recommendations

Several recommendations should be made to reduce vaccine refusal and reluctance rates in the study population. For example, the vaccine development process must be more transparent and clearly explained by healthcare bodies to properly address the doubts of the general population. A proper communication and effective messages could be adequate strategies to increase public confidence in vaccine safety and efficacy, even for those who are already ready to be vaccinated.

Involving vaccine communication experts and the public in developing long-term vaccine messages and strategies is crucial, and governments around the world should start preparing for these strategies imminently.

The implementation of essential immunization programs is posing and will pose significant challenges. The use of several strategies is recommended to reduce barriers to vaccination.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

The ethical approval was obtained from the ethical committee of Ibn Al Jazzar University Hospital, Kairouan, Tunisia (014-2021).

CONSENT FOR PUBLICATION

All methods were carried out in accordance with relevant guidelines and regulations or declaration of Helsinki. Informed consent was obtained electronically, with participants explicitly confirming their willingness to partake in the study before proceeding with the questionnaire.

COMPETING INTERESTS

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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AUTHORS' CONTRIBUTIONS

N.G and M.B.A: conception and design.

N.G, H.G and M.R: analysis and interpretation of the data.

N. G, M.S and N.C: drafting of the paper.

N.G, M.B.A, J.W, J.D.K.S, B.M, H.J, G.H, M.S: investigation.

L.N.B: revising it critically for intellectual content.

All authors gave their final approval to the version that will be published.

DECLARATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Any datasets generated during and/or analyzed during the current study are publicly available, available upon reasonable request, or if data sharing is not applicable to this article.

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