

# Predictors of COVID-19 Vaccine Uptake in Healthcare Workers

## A Cross-Sectional Study in Greece

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**Objective:** We assessed the uptake of a COVID-19 vaccine and associated factors in a sample of healthcare workers (HCWs). **Methods:** An on-line cross-sectional study with 885 HCWs was conducted in Greece during August 2021. We measured socio-demographic data of HCWs and attitudes towards vaccination and the COVID-19 pandemic. A convenience sample was used since the questionnaire was distributed through social media and emails. **Results:** The majority of HCWs were vaccinated against the COVID-19 (91.5%). Females and HCWs with a history of seasonal influenza vaccination had a greater probability to get a COVID-19 vaccine. Also, increased self-perceived knowledge regarding the COVID-19 pandemic and increased trust in COVID-19 vaccines were associated with COVID-19 vaccine uptake. **Conclusions:** Policymakers and scientists should develop novel strategies to improve COVID-19 vaccine uptake among HCWs.

**Keywords:** attitudes, COVID-19, Greece, healthcare workers, vaccine uptake

Around the world, several vaccines have been proven effective in preventing Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and are being widely used.<sup>1-4</sup> The widespread use of COVID-19 vaccines is critical to control the COVID-19 pandemic, but several reasons could delay or decline COVID-19 vaccine uptake. According to a systematic review, the most important reasons for decline of vaccination for COVID-19 are concerns

about the safety and effectiveness of the COVID-19 vaccines, medical conditions, religious and ethical reasons, pregnancy, fertility, limited knowledge, and previous COVID-19 diagnosis.<sup>5</sup> Hesitancy toward a covid-19 vaccine limits general population protection from SARS-CoV-2. This is aggravated in the case of healthcare workers (HCWs), as they have a higher exposure and transmission risk of the SARS-CoV-2 and may potentially endanger themselves, their co-workers and their patients.

To the best of our knowledge, literature regarding COVID-19 vaccine uptake among HCWs is still poor; six studies have been conducted in this field and only one in Europe.<sup>6-11</sup> Respective results showed that the uptake of a COVID-19 vaccine among HCWs is rather different, ranging from 33.3% in the Kingdom of Saudi Arabia<sup>6</sup> and 64.5% in the United Kingdom,<sup>8</sup> to 86.2% in China<sup>11</sup> and 94.5% in the United States.<sup>10</sup> Moreover, according to a meta-analysis that included 24 studies and 39,617 participants worldwide, HCWs' intention to accept COVID-19 vaccination is moderate (63.5%).<sup>12</sup> Several socio-demographic factors increase HCWs' uptake of a COVID-19 vaccine, for example, male gender, older age, higher educational level, white race, etc.<sup>5</sup>

Up-to-date, only one study on the actual acceptance of a COVID-19 vaccine in HCWs in Europe is reported.<sup>8</sup> Moreover, research until now focuses only on socio-demographic determinants of COVID-19 vaccine uptake in HCWs. Thus, we aimed to estimate the uptake of a COVID-19 vaccine in a sample of HCWs in Greece and to expand our knowledge regarding the predictors of COVID-19 vaccine uptake.

## METHODS

### Study Design and Participants

An on-line cross-sectional study was conducted in Greece during August 2021. From January 2021 until the time of the study, a free of charge COVID-19 vaccine was offered from the Greek government to all HCWs throughout the country. The vaccine was taken on a voluntary basis and was offered irrespective of past history of COVID-19. We used Google forms to create an anonymous version of the study questionnaire. A convenience sample was used since the questionnaire was distributed through social media and e-mails. In particular, investigators posted the questionnaire on their Facebook wall and on specific groups on Facebook concerning HCWs. Moreover, the questionnaire was sent to the investigators' electronic contacts by e-mail. As a result, it was not possible to measure the response rate. The on-line questionnaire was accompanied by a detailed explanation of the study aim and design, and the choice for HCWs to provide their informed consent in order to participate anonymously in the study. HCWs completed the questionnaire on a voluntary basis without receiving any financial reward. All HCWs over 18 years old were allowed to participate in the study. The Department of Nursing, National and Kapodistrian University of Athens approved the study design (reference number; 370, 02-09-2021).

### Sample Size and Power

Given the wide range of COVID-19 vaccine uptake amongst the HCWs in prior studies, a 50% conservative estimate of

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The authors report no conflicts of interest.

Clinical significance: Our study provides a timely assessment of COVID-19 vaccination status among healthcare workers and identifies specific factors associated with COVID-19 vaccine uptake. By understanding these factors, policymakers and scientists will be able to develop novel strategies to improve COVID-19 vaccine uptake among healthcare workers.

Data availability statement: Data available on request.

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prevalence was considered appropriate in order to estimate the sample size of our study. Thus, considering the prevalence of COVID-19 vaccine uptake as 50%, precision level as 5%, and confidence level as 95%, a minimum sample size of 385 HCWs was set. Twenty-three predictor variables were used and a minimum number of 230 vaccinated HCWs were included in our study so as to perform a valid multivariate regression analysis.<sup>13</sup> Finally, a sample size substantial increase was in order to minimize random error.

**Questionnaire**

The following socio-demographic data of HCWs were collected: gender, age, marital status, under-age children, educational level, profession, years of experience, self-perceived financial status, self-perceived health status, chronic disease, previous COVID-19 diagnosis, family/friends with previous COVID-19 diagnosis, living with elderly people or vulnerable groups during the COVID-19 pandemic, and providing care to COVID-19 patients. HCWs' profession was collapsed into the following categories: physicians, nurses, administrative staff, paramedics, nurses' assistants, and others. Financial status and self-perceived health status were measured in a five-point Likert scale from 0 to 4 (0 = "very poor," 1 = "poor," 2 = "moderate," 3 = "good," and 4 = "very good").

Regarding vaccination, seasonal influenza vaccination in 2020 and COVID-19 vaccination were measured with yes/no answers. Moreover, possible reasons for the decline of vaccination for COVID-19 were recorded, for example, concerns about the safety and effectiveness of COVID-19 vaccines, fear for side effects, religious reasons, pregnancy, previous COVID-19 diagnosis, etc.

Also, self-perceived severity of the COVID-19 pandemic, self-perceived knowledge regarding the COVID-19 pandemic and COVID-19 vaccines, concerns about the side effects of COVID-19 vaccination, trust in COVID-19 vaccines, and trust in the government, scientists, and family doctors regarding the information about the COVID-19 vaccines were measured on a scale from 0 to 10 with higher values indicating higher levels of self-perceived severity of the COVID-19 pandemic, knowledge, concerns, and trust. The relationship between these predictors and COVID-19 vaccination uptake among HCWs has not been studied so far in other studies. Each predictor was assessed via a single item and no separate scale was created.

**Statistical Analysis**

We used frequencies (percentages) to present categorical variables and mean (standard deviation) to present continuous variables. The Kolmogorov-Smirnov test and normal Q-Q plots were applied to test the normality of the distribution of the continuous variables. Questionnaires with more than 5% of missing data (n = 3) were excluded from the analysis. COVID-19 vaccination was the dependent variable and the outcome was defined as 1 if a HCW took a COVID-19 vaccine. First, we performed univariate logistic regression analysis with each predictor and outcome in order to determine bivariate associations; then all of the independent variables were included in a multivariate logistic regression model so as to eliminate confounding. Adjusted odds ratios, 95% confidence intervals, and P-values were also calculated. In multivariate logistic regression model, P-values < 0.05 were considered significant. All tests of statistical significance were two-tailed. Statistical analysis was performed with the Statistical Package for Social Sciences software (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.).

**RESULTS**

Study population included 855 HCWs. Detailed socio-demographic characteristics of the participating HCWs are shown in Table 1. Mean age of HCWs was 40.9 years and the mean value of years of clinical experience was 14.4. Among HCWs, 80.7% were females, 48.9% had a MSc/PhD degree, 45.3% were nurses, and

**TABLE 1.** Socio-Demographic Characteristics of Healthcare Workers (n = 885)

Characteristics	N	%
Gender		
Females	714	80.7
Males	171	19.3
Age (years)*	40.9	9.9
Marital status		
Singles	254	28.7
Married	565	63.8
Widowed	61	6.9
Divorced	5	0.6
Children < 18 years old		
No	398	45.0
Yes	487	55.0
MSc/PhD degree		
No	452	51.1
Yes	433	48.9
Profession (n = 874)		
Physicians	220	25.2
Nurses	396	45.3
Nurses assistants	47	5.4
Midwives	16	1.8
Paramedics	73	8.4
Administrative staff	72	8.2
Pharmacists	28	3.2
Biochemists	7	0.8
Dentists	5	0.6
Ambulatory staff	10	1.1
Clinical experience (years)*	14.4	9.5
Self-perceived financial status		
Very poor	10	1.1
Poor	80	9.0
Moderate	483	54.6
Good	257	29.0
Very good	55	6.2
Self-perceived health status		
Very poor	3	0.3
Poor	17	1.9
Moderate	140	15.8
Good	446	50.4
Very good	279	31.5
Chronic disease		
No	707	79.9
Yes	178	20.1
Previous COVID-19 diagnosis		
No	789	89.2
Yes	96	10.8
Family/friends with previous COVID-19 diagnosis		
No	365	41.2
Yes	520	58.8
Living with elderly people or vulnerable groups during the COVID-19 pandemic		
No	626	70.7
Yes	259	29.3
Providing care to COVID-19 patients (n = 879)		
No	441	50.2
Yes	438	49.8

\*Mean, standard deviation.

20.1% had suffered from a chronic disease. Regarding the COVID-19 pandemic, 10.8% of HCWs were diagnosed with COVID-19, 58.8% had family/friends with a previous COVID-19 diagnosis, and 49.8% provided care to COVID-19 patients. Most of the HCWs considered their financial status as moderate/good (83.6%) and their health status as good/very good (81.9%).

**TABLE 2.** Healthcare Workers' Attitudes Toward COVID-19 Vaccination and Pandemic (n = 885)

Characteristics	N	%
COVID-19 vaccination		
No	75	8.5
Yes	810	91.5
Seasonal influenza vaccination in 2020		
No	313	35.4
Yes	572	64.6
Reasons for decline of COVID-19 vaccination (n = 74)		
I have doubts about the safety and effectiveness of COVID-19 vaccines	37	50.0
I am afraid of side effects of COVID-19 vaccines	13	17.6
I believe that I will not be infected by COVID-19	0	0
I believe that even if I get infected with COVID-19, nothing bad will happen to me	2	2.7
I have already been diagnosed with COVID-19 and the vaccine will not be beneficial for me	9	12.2
I am afraid because I suffer from a chronic disease	3	4.1
Family physician does not allow me to take a COVID-19 vaccine due to my medical condition	0	0
My religion does not allow me to take a COVID-19 vaccine	0	0
I am trying to get pregnant	7	9.5
I am afraid because I am pregnant	3	4.1
Self-perceived severity of COVID-19*	8.3	2.1
Self-perceived knowledge regarding COVID-19*	9.1	1.3
Information regarding COVID-19 vaccines*	8.7	1.7
Concerns about the side effects of COVID-19 vaccination*	5.6	3.1
Trust in COVID-19 vaccines*	7.5	2.6
Trust in the government regarding the information about the COVID-19 vaccines*	5.5	3.2
Trust in scientists regarding the information about the COVID-19 vaccines*	7.6	2.8
Trust in family doctors regarding the information about the COVID-19 vaccines*	8.2	2.1

\*Mean, standard deviation.

Table 2 presents HCWs' attitudes towards COVID-19 vaccination and the pandemic. The majority of HCWs were vaccinated against the COVID-19 (n = 810, 91.5%), while the respective percentage for seasonal influenza in 2020 was 64.6% (n = 572). The most important reasons for decline of vaccination for COVID-19 (n = 74) were concerns about the safety and effectiveness of the COVID-19 vaccines (n = 37, 50%), concerns about the side effects of the COVID-19 vaccines (n = 13, 17.6%), previous COVID-19 diagnosis (n = 9, 12.2%), and females' effort to get pregnant (n = 7, 9.5%). HCWs reported high levels of knowledge regarding the COVID-19 pandemic and COVID-19 vaccines and moderate concerns about the respective side effects. Regarding the sources of information about the COVID-19 vaccines, HCWs showed more trust in family doctors and scientists than the government.

Unadjusted associations between the predictor variables and vaccination status are shown in Table 3, while multivariate logistic regression analysis is shown in Table 4. According to multivariate analysis's results, seven variables were related to COVID-19 vaccine uptake in healthcare workers. In particular, females and HCWs with previous seasonal influenza vaccination history had a greater probability to take a COVID-19 vaccine. Increased self-perceived knowledge regarding COVID-19 pandemic and increased trust in COVID-19 vaccines were associated with COVID-19 vaccine uptake. On the other hand, HCWs with more concerns about the side effects of COVID-19 vaccination were more reluctant to take a COVID-19 vaccine. Moreover, increased information regarding COVID-19 vaccines and increased trust in family doctors were associated with COVID-19 vaccine hesitancy.

**DISCUSSION**

A study to estimate COVID-19 vaccine uptake in a sample of HCWs in Greece and investigate the predictors of this uptake was conducted. The majority of HCWs (91.5%) had been vaccinated against the COVID-19. This percentage identifies with the one found in studies in the United States (94.5%) and China (86.2%).<sup>10,11</sup> On the

contrary, lower COVID-19 vaccine uptake (from 33.3% to 79%) was reported in four studies in the United States, United Kingdom, and Kingdom of Saudi Arabia found.<sup>6-9</sup> Data collection time may explain this variability in COVID-19 vaccine uptake, as the closer to September 2021 each study was conducted, the more likely HCWs were to take a COVID-19 vaccine. At the time of our study, COVID-19 vaccination for HCWs was voluntary in Greece, but the government was planning a mandatory vaccination program for HCWs and other occupational groups since September 2021. The intention of the Greek government may partially explain the high percentage of COVID-19 vaccine uptake in HWCs in our study.

Our multivariate regression model revealed varied factors were associated with COVID-19 vaccine uptake in HCWs. In particular, trust in COVID-19 vaccines and fewer concerns about the side effects of COVID-19 vaccination were associated with vaccine acceptance. This finding is confirmed by the literature as the main reasons for the decline of vaccination for COVID-19 include concerns about the COVID-19 vaccine safety and effectiveness.<sup>10,11</sup> Thus, policymakers and scientists should provide unvaccinated HCWs with more data on safety and surveillance about the COVID-19 vaccines.

Moreover, we found that increased information regarding COVID-19 vaccines was associated with COVID-19 vaccine hesitancy. High level of information does not necessarily reflect adequate knowledge regarding COVID-19 vaccines as many sources of information during the COVID-19 pandemic (eg, social media, religious leaders, etc.) were and may still be false and misleading. Detection of fake news is associated with the intention to take a COVID-19 vaccine.<sup>14</sup> Also, COVID-19 vaccine uptake is higher among individuals that do not use social media as a source of information during the COVID-19 pandemic.<sup>6</sup> Research indicates that on-line information related to the COVID-19 pandemic published in many websites is of poor quality and rather inadequate.<sup>15-17</sup> Additionally, information regarding COVID-19 vaccines is of particular interest, as these vaccines are innovative

**TABLE 3.** Unadjusted Associations Between the Predictor Variables and COVID-19 Vaccination Status (Reference: COVID-19 Vaccine Denial)

Variable	Vaccinated Healthcare Workers		Unadjusted Odds Ratio (95% Confidence Interval)	P
	No	Yes		
Gender*			1.47 (0.85–2.54)	0.17
Females	56 (7.8)	658 (92.2)		
Males	19 (11.1)	152 (88.9)		
Age (years) <sup>†</sup>	40.3 (10.3)	41.0 (9.9)	1.01 (0.98–1.03)	0.59
Marital status*			1.12 (0.69–1.83)	0.64
Married	46 (8.1)	519 (91.9)		
Singles/widowed/divorced	29 (9.1)	291 (90.9)		
Children < 18 years old*			1.71 (1.04–2.81)	0.04
No	25 (6.3)	373 (93.7)		
Yes	50 (10.3)	437 (89.7)		
MSc/PhD degree*			1.32 (0.82–2.13)	0.26
Yes	32 (7.4)	401 (92.6)		
No	43 (9.5)	409 (90.5)		
Profession*				
Physicians	13 (5.9)	207 (94.1)	4.31 (1.76–10.54)	0.001
Nurses	31 (7.8)	365 (92.2)	3.18 (1.45–7.00)	0.004
Administrative staff	8 (11.1)	64 (88.9)	2.16 (0.78–5.96)	0.14
Paramedics	7 (9.6)	66 (90.4)	2.55 (0.89–7.26)	0.08
Others	4 (6.1)	62 (93.9)	4.19 (1.23–14.32)	0.02
Nurses assistants	10 (21.3)	37 (78.7)	1 (reference)	
Clinical experience <sup>†</sup>	13.8 (9.4)	14.5 (9.5)	1.01 (0.98–1.04)	0.54
Self-perceived financial status <sup>*‡</sup>				
Good/very good	24 (7.7)	288 (92.3)	2.59 (1.31–5.13)	0.006
Moderate	35 (7.2)	448 (92.8)	2.77 (1.46–5.25)	0.002
Very poor/poor	16 (17.8)	74 (82.2)	1 (reference)	
Self-perceived health status <sup>*‡</sup>				
Good/very good	59 (8.1)	666 (91.9)	2.82 (0.91–8.72)	0.07
Moderate	12 (8.6)	128 (91.4)	2.67 (0.77–9.26)	0.12
Very poor/poor	4 (20.0)	16 (80.0)	1 (reference)	
Chronic disease*			1.01 (0.56–1.92)	0.98
Yes	15 (8.4)	163 (91.6)		
No	60 (8.5)	647 (91.5)		
COVID-19 disease*			2.96 (1.66–5.29)	<0.001
No	57 (7.2)	732 (92.8)		
Yes	18 (18.8)	78 (81.3)		
Family/friends with COVID-19 disease*			1.77 (1.06–2.97)	0.03
No	22 (6.0)	343 (94.0)		
Yes	53 (10.2)	467 (89.8)		
Living with elderly people or vulnerable groups during the COVID-19 pandemic*			1.40 (0.85–2.30)	0.18
No	48 (7.7)	578 (92.3)		
Yes	27 (10.4)	232 (89.6)		
Providing care to COVID-19 patients*			1.01 (0.63–1.62)	0.98
No	37 (8.4)	404 (91.6)		
Yes	37 (8.4)	401 (91.6)		
Seasonal influenza vaccination in 2020*			7.43 (4.24–13.01)	<0.001
Yes	17 (3.0)	555 (97.0)		
No	58 (18.5)	255 (81.5)		
Self-perceived severity of COVID-19 <sup>†</sup>	5.8 (2.7)	8.5 (1.9)	1.56 (1.42–1.72)	<0.001
Self-perceived knowledge regarding COVID-19 <sup>†</sup>	8.8 (1.8)	9.1 (1.2)	1.17 (1.01–1.35)	0.04
Information regarding COVID-19 vaccines <sup>†</sup>	8.4 (1.9)	8.8 (1.6)	1.12 (0.99–1.26)	0.09
Concerns about the side effects of COVID-19 vaccination <sup>†</sup>	8.7 (2.2)	5.3 (3.0)	0.56 (0.48–0.64)	<0.001
Trust in COVID-19 vaccines <sup>†</sup>	2.9 (3.2)	7.9 (2.1)	1.77 (1.61–1.94)	<0.001
Trust in the government regarding the information about the COVID-19 vaccines <sup>†</sup>	2.0 (2.6)	5.9 (3.1)	1.55 (1.41–1.72)	<0.001
Trust in scientists regarding the information about the COVID-19 vaccines <sup>†</sup>	3.8 (3.3)	7.9 (2.4)	1.52 (1.40–1.65)	<0.001
Trust in family doctors regarding the information about the COVID-19 vaccines <sup>†</sup>	6.5 (3.1)	8.4 (1.9)	1.38 (1.26–1.51)	<0.001

An odds ratio < 1 indicates a negative association, while an odds ratio > 1 indicates a positive association.

\*Values are expressed as n (%).

<sup>†</sup>Values are expressed as mean (standard deviation).

<sup>‡</sup>Due to low number of healthcare workers, we merged the following categories: “very poor” and “poor”; “good” and “very good.”

**TABLE 4.** Multivariate Logistic Regression Analysis with COVID-19 Vaccine Uptake in Healthcare Workers as the Dependent Variable (Reference: COVID-19 Vaccine Denial)

Variable	Adjusted Odds Ratio (95% Confidence Interval)*	P
Gender (females vs males)	3.36 (1.11–10.23)	0.03
Age (years)	1.02 (0.94–1.09)	0.67
Marital status (married vs singles/widowed/divorced)	1.06 (0.45–2.54)	0.89
Children < 18 years old (no vs yes)	1.54 (0.62–3.79)	0.35
MSc/PhD degree (yes vs no)	0.91 (0.41–2.01)	0.82
Profession		
Physicians	1.38 (0.27–7.04)	0.69
Nurses	1.99 (0.56–7.11)	0.29
Administrative staff	1.65 (0.29–9.44)	0.57
Paramedics	1.20 (0.17–8.29)	0.85
Others	2.62 (0.47–14.56)	0.27
Nurses assistants		
Clinical experience	1.01 (0.94–1.09)	0.83
Self-perceived financial status <sup>†</sup>		
Good/very good	0.42 (0.12–1.46)	0.42
Moderate	0.84 (0.28–2.53)	0.75
Very poor/poor Self-perceived health status <sup>†</sup>		
Good/very good	2.08 (0.27–15.79)	0.48
Moderate	1.29 (0.17–9.68)	0.80
Very poor/poor		
Chronic disease (yes vs no)	0.86 (0.31–2.35)	0.76
COVID-19 disease (no vs yes)	2.43 (0.90–6.53)	0.08
Family/friends with COVID-19 disease (no vs yes)	1.86 (0.79–4.36)	0.16
Living with elderly people or vulnerable groups during the COVID-19 pandemic (no vs yes)	1.63 (0.72–3.69)	0.24
Providing care to COVID-19 patients (no vs yes)	0.60 (0.26–1.37)	0.23
Seasonal influenza vaccination in 2020 (yes vs no)	4.25 (1.86–9.75)	0.001
Self-perceived severity of COVID-19	1.17 (0.99–1.39)	0.07
Self-perceived knowledge regarding COVID-19	1.47 (1.06–2.04)	0.02
Information regarding COVID-19 vaccines	0.64 (0.49–0.83)	0.001
Concerns about the side effects of COVID-19 vaccination	0.70 (0.58–0.85)	<0.001
Trust in COVID-19 vaccines	1.45 (1.18–1.78)	<0.001
Trust in the government regarding the information about the COVID-19 vaccines	1.16 (0.98–1.39)	0.09
Trust in scientists regarding the information about the COVID-19 vaccines	1.08 (0.89–1.31)	0.44
Trust in family doctors regarding the information about the COVID-19 vaccines	0.81 (0.67–0.98)	0.04

An odds ratio < 1 indicates a negative association, while an odds ratio > 1 indicates a positive association.

\*R<sup>2</sup> for the final multivariate model was 62%.

<sup>†</sup>Due to low number of healthcare workers, we merged the following categories: “very poor” and “poor”; “good” and “very good.”.

and new data is constantly emerging. Governments should develop strategies to regulate the COVID-19 pandemic information circulating on the internet ensuring that websites shall provide evidence-based information related to COVID-19 vaccines.

Our findings demonstrate higher COVID-19 vaccine uptake among HCWs with previous seasonal influenza vaccination history. The role of influenza vaccination in the uptake of the COVID-19 vaccine in HCWs has not yet been investigated in other studies but has already proved to be critical in the intention of HCWs to accept a COVID-19 vaccine.<sup>12</sup> Unfortunately, the influenza vaccination rate amongst HCWs is low, even though it is higher than the one detected in general population and high-risk groups.<sup>18–21</sup> Refusal of influenza vaccination is evidence of vaccine hesitancy, one of the top 10 threats to global health in 2019 according to the World Health Organization.<sup>22</sup> Moreover, COVID-19 vaccine hesitancy in HCWs is crucial as it can undermine public confidence.<sup>23,24</sup> Educational programs and workplace strategies are proven effective to improve influenza vaccination coverage amongst HCWs and may also serve as a guide to improve COVID-19 vaccine uptake.<sup>25</sup>

We also found that females had greater COVID-19 vaccine uptake than males. This finding is interesting as it opposes to the results of previous studies.<sup>6,8–10</sup> In general, COVID-19 vaccine

hesitancy is more common among females.<sup>26–30</sup> Our finding may be so due to the fact that we currently have more knowledge about the safety and effectiveness of COVID-19 vaccines. For instance, the results of recent studies show the effectiveness of vaccines in both pregnant and lactating women.<sup>31,32</sup>

### Limitations

Our study suffers from several limitations. Although study population was large, we used a convenience sample which is not representative of the mix of HCWs in Greece. For instance, the females/males ratio in our study was 4:1 indicating a greater participation of females. Moreover, only 50% of the HCWs in our sample were providing care to COVID-19 patients. However, if that number was higher, our results would probably not be affected since the vaccination rate was equal for both HCWs who provided care to COVID-19 patients and those who did not. Additionally, the response rate could not be calculated as we conducted an on-line study. Moreover, vaccine uptake and other information were self-reported and social desirability to bias responses may exist. For instance, some HCWs may have falsely stated that they had received a COVID-19 vaccine. We used an anonymous on-line questionnaire to reduce this bias. Furthermore, we investigated a variety of determinants of

COVID-19 vaccine uptake and some of them had not been studied before. However, it is possible that there are other factors affecting COVID-19 vaccination. For instance, we did not take into consideration the setting in which the HCWs worked (eg, primary care, COVID-19 clinic, emergency department, outpatient clinic, etc.) Future research may consider including other factors which may influence COVID-19 vaccine uptake, for example, personality traits, social media variables, fake news, conspiracy theories, etc. Another limitation of our study is the fact that we did not use validated scales/questionnaires to measure severity/fear/safety concerns, etc. but we used single items to measure all constructs. Finally, as is always the case in cross-sectional studies, no causal relationships between independent variables and COVID-19 vaccine uptake can be established.

## CONCLUSIONS

Our study provides a timely assessment of COVID-19 vaccination status among HCWs in Greece and identifies specific factors associated with COVID-19 vaccine uptake. Future work is needed to understand the factors influencing the decision of HCWs to vaccinate against the COVID-19. By understanding these factors, policymakers and scientists will be able to develop novel strategies to improve COVID-19 vaccine uptake amongst HCWs. The role of HCWs in the general public health is crucial and their decision to vaccinate can have a positive impact on the general population facilitating the widespread COVID-19 vaccine uptake.

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