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Vaccine 40 (2022) 6271–6276

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

# COVID-19 vaccine hesitancy among Israeli adults before and after vaccines' availability: A cross-sectional national survey

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ARTICLE INFO

*Article history:*
Received 7 April 2022
Received in revised form 17 July 2022
Accepted 3 August 2022
Available online 14 September 2022

*Keywords:*
COVID-19
Israel
SARS-CoV-2
Vaccine hesitancy
Vaccine uptake

ABSTRACT

Vaccine hesitancy (VH) is a major health threat to the efforts to tackle COVID-19 morbidity and mortality. This study's objectives were to assess COVID-19 VH before and after vaccines' availability and to analyze the associations between COVID-19 VH and participants' characteristics.

A national cross-sectional telephone interview survey among Israeli adults aged 21 and older was conducted from September 2020 through May 2021. Attitudes towards COVID-19 vaccines were assessed pre/post vaccines' availability. Multivariate logistic regression analyses were used to identify associations between demographic and health-related characteristics and COVID-19 VH.

Most study participants (72.0 % of 2,998) were willing to be vaccinated against COVID-19 across the survey period. The COVID-19 VH declined significantly from 45.6 % pre-vaccine availability to 16.3 % post-vaccine availability ($P < 0.001$). The multivariable analysis demonstrated that post-vaccine availability, COVID-19 VH was associated with younger age, Arab ethnicity, higher level of religiosity, lower education, past diagnosis of COVID-19, and influenza VH. The main reasons for VH after the vaccine availability included insufficient data on the vaccine (37.4 %) and fear of the vaccine's side effects (33.8 %).

Despite the significant decrease in COVID-19 VH following vaccine availability, 16.3% of the population still refuses to get vaccinated. As Israel may face additional waves of the COVID-19 pandemic and booster vaccinations, multimedia vaccine promotions targeting the above-mentioned hesitant populations and their reasons for VH are urgently needed.

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## 1. Introduction

Vaccine hesitancy (VH), defined as a delay or even refusal to be vaccinated, is a major threat to global health since it contributes to the continuation of infectious diseases' spread and resurgence [1–3]. Regarding COVID-19, most studies have demonstrated a country-specific COVID-19 vaccination acceptance level of $\geq$ 70 % [4,5]. Lower rates of acceptance were reported in the Middle East, Russia, Africa, and several European countries [4]. Various factors were found to be associated with potential COVID-19 VH, including younger age, female gender, ethnic groups, lower education, unemployment, having children in the household, perceived low risk of contracting COVID-19, and poor compliance with other recommended vaccines [5–8]. Potential COVID-19 VH was associated also with vaccine-related attributes (e.g., vaccine efficacy, adverse effects, and protection duration) and political factors (e.g., vaccines' approval process, national origin of vaccine, and endorsements) [9,10].

On December 20th, 2020, Israel initiated a nationwide COVID-19 vaccination campaign with the BNT162b2 Pfizer-BioNTech mRNA vaccine. The campaign was aimed first towards the elderly, healthcare providers, and chronically-ill, and expanded gradually to other age groups. By February 2021, all people aged $\geq$ 16 years were eligible for COVID-19 vaccination. While COVID-19 vaccination campaigns are still ongoing worldwide, there is growing evidence that the efficacy of the two dosage 21-

*Abbreviations:* VH, Vaccine hesitancy; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

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https://doi.org/10.1016/j.vaccine.2022.08.070
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days apart regime is waning after five months [11] alongside continuous emergence of new COVID-19 strains, alerting to the necessity of additional booster vaccinations. It is, therefore, essential to identify the factors associated with VH, before and after vaccine availability. Hence, the primary objective of this study was to assess COVID-19 VH before and after vaccines' availability. A secondary aim was to analyze the association between COVID-19 VH and participants' characteristics. This information is extremely valuable for developing public health policies and communication strategies for promoting the uptake of the vaccines in reluctant populations as a means to terminate the vicious cycle of continuous transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) among partly immune populations and in the aftermath of waning immunity and emergence of new strains.

## 2. Methods

### 2.1. Survey design and population

This study is based on data from a national cross-sectional telephone interview health survey conducted by the Israel Center for Disease Control, Ministry of Health, from September 2020 until May 2021. The survey spanned two time periods: from September through December 2020, before the COVID-19 vaccines were available (phase 1), and from December 20th, 2020 through May 2021, during the COVID-19 vaccination campaign (phase 2).

A random sample of telephone numbers (mobile and landline) of Jewish and Arab households was extracted. The sample was proportionate to the population's geographic distribution. Households were considered non-eligible and were excluded from the sample if they fulfilled at least one of the following criteria: there was no resident older than 21 years, the residents did not speak Hebrew or Arabic or were unable to complete the questionnaire due to mental or physical disability, and the telephone line was commercial or was disconnected. Households were identified as non-respondents (with unknown eligibility) after 8 failed attempts to make contact. No compliance included outright refusals to participate, partially completed interviews, and repeated postponements.

### 2.2. The questionnaire

Data were collected via a structured questionnaire, using a computer-assisted telephone interview (CATI) system. All variables were based on self-report.

#### 2.2.1. COVID-19 vaccine hesitancy

COVID-19 VH (before the availability of the vaccines) and VH after the vaccines' availability were assessed by asking all participants, ‘‘If a COVID-19 vaccine will be available soon, would you agree to get vaccinated?" or ‘‘As the COVID-19 vaccine is now available, would you agree to get vaccinated?", accordingly, with predefined reply options (yes/no/don't know). For the current analysis, these categories were grouped into two categories, where ‘‘yes" indicated acceptance and ‘‘no/don't know" indicated hesitancy. Participants who answered ‘‘no" were further asked for their main reasons for refusal and multiple answers were allowed. The categorization of the reasons was based on published literature [8] and included: ‘‘I don't think the vaccine will be effective", ‘‘I am afraid of the vaccine's side effects", ‘‘there is insufficient data on the vaccine", ‘‘COVID-19 is not a dangerous disease (no need to be vaccinated)", ‘‘immunity to COVID-19 due to a previous infection" or ‘‘other reason". If the participants answered ‘‘other reason" they were asked to elaborate in their own words.

#### 2.2.2. Sociodemographic variables

Participants reported their age, gender, population group (Jews/Arabs), education ($\leq$12 years/>12 years), level of religiosity (secular or traditional/religious/Ultra-Orthodox or religiously devout Muslims), marital status (married or living with a partner/widowed or separated/single), parity (nulliparous/having children) and current employment status (employed/unemployed).

#### 2.2.3. Health status

Comorbidity was assessed by asking, ‘‘Has a doctor ever diagnosed you with any of the following: hypertension, heart disease, lung disease, diabetes, anxiety and/or depression?" (yes/no for each). Being chronically ill was defined as having at least one of the above-mentioned diseases (yes/no). Respondents were also asked if they had ever been diagnosed with COVID-19 (yes/no).

#### 2.2.4. Influenza VH

Influenza VH was measured by asking, ‘‘Were you vaccinated for seasonal influenza last winter (2019–2020)?" (yes/no), and depending on the phase of the survey, ‘‘Do you intend to be vaccinated with seasonal influenza vaccine this winter (2020–2021)?" or "Have you received influenza vaccine this winter (2020–2021)?‘‘ (yes, I was vaccinated or yes, I intend to be vaccinated/no). For the current analysis, these last categories were grouped into two categories (yes/no), where "yes‘‘ indicated acceptance and "no‘‘ indicated hesitancy.

### 2.3. Statistical analysis

Data were analyzed using SAS Enterprise Guide version 9.4 (SAS Institute Inc., Cary, NC, USA). For the descriptive analysis, percentages were calculated for all variables. All percentages were weighted for population group, age, gender, and landline phone ownership. The Pearson's Chi-square test for categorical variables was used to compare COVID-19 vaccine acceptance/hesitancy by sociodemographic and health-related variables through the whole survey period and by study phases (pre/post-vaccine availability) separately. The Pearson's Chi-square test was also used to compare VH and its reasons between the study's two phases. A logistic regression model was applied to determine the associations between VH and participants' characteristics for the whole study period and by study phases controlling for age, gender, population group, level of religiosity, and education. Also, all variables that were statistically significant at $\alpha < 0.1$ in the univariable analysis were entered into the multivariable analysis. P-value < 0.05 was considered statistically significant.

### 2.4. Ethical approvall

According to Israeli legislation, the Ministry of Health may conduct telephone health surveys, as described herein, for regulatory needs, and they do not require approval of an ethics committee. Therefore, approval of an ethics committee was not needed for this data collection and analysis. Oral informed consent for each participant was obtained after a brief explanation about the health survey, including its objectives and importance. All data were collected anonymously.

## 3. Results

A random sample of telephone numbers of 9,860 households was extracted. After applying the exclusion criteria, a total of 6,058 households remained; of them, 3,024 participants completed the survey, with a response rate of 49.9 %. After excluding 18 inconsistent interviews and eight interviews with missing data,

the sample for analyses included 2,998 participants (1,827 Jews and 1,171 Arabs).

Table 1 presents the demographics and health-related characteristics of the survey participants by VH before (study phase 1) and after (study phase 2) the availability of the COVID-19 vaccine. The majority (72.0 %) of participants were willing to be vaccinated against COVID-19, especially after the vaccine was available to the public (54.4 % vs 83.7 %, P < 0.001). Thus, the COVID-19 VH declined significantly between the two study phases from 45.6 % to 16.3 % (P < 0.001). This decline was especially prominent among women, participants aged 50 and above, not single, with secular or traditional religiosity, higher education, and/or with children (Table 1). A significant decline in COVID-19 VH was also evident among chronically ill participants, those who were never diagnosed with COVID-19, and those who were either vaccinated or intended to get vaccinated against influenza. After the availability of the COVID-19 vaccines, VH was significantly more prevalent among younger participants, Arabs, and participants who were religious, single, with no children, without chronic diseases, and who were not vaccinated nor intended to get vaccinated with the influenza vaccine. Moreover, VH was more prevalent among participants previously diagnosed with COVID-19. The multivariable logistic regression analyses (Table 2) show that COVID-19 VH after the availability of the vaccine was associated with younger age, Arab ethnicity, higher level of religiosity, lower education, past diagnosis of COVID-19, and influenza VH in the past winter. The regression analysis for the whole study period (Table 3) shows that the odds of VH were reduced by 84.0 % post-vaccine availability.

Table 4 demonstrates the main reasons for VH among participants by survey period. Although insufficient data on the vaccine was the main reason for VH before and after the vaccine availability, its frequency declined significantly between the two study phases (54.3 % vs 37.4 %, P < 0.001). On the other hand, fear of the vaccine's side effects as a reason for VH rose after vaccine availability (26.2 % vs 33.8 %, P = 0.05).

## 4. Discussion

On December 20th, 2020, Israel launched its COVID-19 vaccination campaign with the BNT162b2 Pfizer-BioNTech mRNA vaccine [4,12]. The current study examined the Israeli adult citizens' COVID-19 VH before and after the vaccine's availability to the pop-

**Table 1**
Demographics and health-related characteristics of the survey participants by survey period and vaccine hesitancy, September 2020 – May 2021.

| Variable[a] | Study phase 1: Before vaccine availability | | | Study phase 2: After vaccine availability | | |
|---|---|---|---|---|---|---|
| | 8th Sept–19th Dec 2020 n, (%) | | | 20th Dec 2020 – 9th May 2021 n, (%) | | |
| | Vaccine hesitancy (N = 581) | Vaccine acceptance (N = 618) | P value | Vaccine hesitancy (N = 293) | Vaccine acceptance (N = 1,506) | P value |
| Age group[b] | | | | | | |
| 21–34 | 100 (29.3) | 109 (33.0) | 0.234 | 55 (41.2) | 209 (29.5) | <0.001 |
| 35–49 | 184 (32.4) | 161 (27.2) | | 114 (34.3) | 428 (28.6) | |
| | 162 (22.1) | 191 (22.7) | | 82 (17.2) | 493 (23.4) | |
| | 135 (16.2) | 157 (17.1) | | 42 (7.3) | 376 (18.5) | |
| **Gender**[b] | | | | | | |
| Male | 248 (41.0) | 3339 (55.3) | <0.001 | 147 (49.7) | 762 (48.6) | 0.726 |
| Female | 333 (59.0) | 279 (44.7) | | 146 (50.3) | 744 (51.4) | |
| **Population group** | | | | | | |
| | 375 (76.8) | 472 (85.5) | <0.001 | 119 (75.4) | 861 (82.7) | 0.003 |
| | 206 (23.2) | 146 (14.5) | | 174 (24.6) | 645 (17.3) | |
| **Level of religiosity**[b] | | | | | | |
| Secular/Traditional | 397 (70.5) | 455 (72.8) | 0.389 | 158 (52.9) | 1,134 (75.5) | <0.001 |
| Religious | 118 (17.8) | 102 (18.0) | | 82 (19.0) | 263 (15.3) | |
| Ultra-Orthodox/Religiously devout | 47 (11.7) | 40 (9.2) | | 39 (28.1) | 77 (9.3) | |
| **Years of education**[b] | | | | | | |
| ≤12 | 205 (27.3) | 171 (22.5) | 0.059 | 129 (34.4) | 531 (29.4) | 0.091 |
| >12 | 360 (72.7) | 436 (77.5) | | 160 (65.6) | 953 (70.6) | |
| **Marital status**[b] | | | | | | |
| Married/living with a partner | 436 (73.6) | 482 (73.8) | 0.302 | 215 (65.6) | 1,151 (70.3) | 0.027 |
| Separated /widowed | 79 (11.0) | 70 (8.7) | | 31 (7.8) | 177 (9.9) | |
| Single | 54 (15.4) | 62 (17.5) | | 44 (26.6) | 162 (19.8) | |
| **Parity**[b] | | | | | | |
| Nulliparous | 68 (19.9) | 84 (22.9) | 0.206 | 56 (32.3) | 202 (23.4) | 0.001 |
| Having children | 496 (80.1) | 529 (77.1) | | 231(67.7) | 1,286 (76.6) | |
| **Ever diagnosed with COVID-19**[b] | | | | | | |
| Yes | 32 (5.9) | 24 (3.2) | 0.022 | 54 (23.6) | 140 (8.6) | <0.001 |
| No | 547 (94.1) | 592 (96.8) | | 239 (76.4) | 1,364 (91.4) | |
| **Chronically ill**[b,c] | | | | | | |
| Yes | 195 (31.0) | 240 (33.4) | 0.390 | 92 (21.9) | 552 (31.2) | 0.001 |
| No | 375 (69.0) | 374 (66.6) | | 200 (78.1) | 937 (68.8) | |
| **Vaccinated for Influenza last winter (2019–2020)**[b] | | | | | | |
| Yes | 210 (35.2) | 316 (49.0) | <0.001 | 71 (20.8) | 665 (43.6) | <0.001 |
| No | 362 (64.8) | 293 (51.0) | | 219 (79.2) | 824 (56.4) | |
| **Intended or actual vaccinated for Influenza in current winter (2020–2021)**[b] | | | | | | |
| Yes | 245 (46.9) | 416 (71.1) | <0.001 | 68 (19.9) | 702 (45.1) | <0.001 |
| No | 288 (53.1) | 161 (28.9) | | 215 (80.1) | 774 (54.9) | |

[a] Rates were weighted for population groups, age, gender, and landline phone ownership.
[b] Significant change (p < 0.05) in vaccine hesitancy rate between the survey's two time periods.
[c] Hypertension and/or heart disease and/or lung disease and/or diabetes and/or anxiety/depression.

**Table 2**
Adjusted[a] odds ratios (ORs) for the associations between vaccine hesitancy and participants' characteristics by survey period.

| Variable | Before vaccine availability 8th Sept 2020 – 19th Dec 2020 | | | After vaccine availability 20th Dec 2020 – 8th May 2021 | | |
|---|---|---|---|---|---|---|
| | OR | CI 95% | P value | OR | CI 95% | P value |
| **Age**[b] | 1.00 | 0.99–1.01 | 0.552 | 0.98 | 0.97–0.99 | 0.002 |
| **Gender** | | | | | | |
| Male | 1 (Ref) | | | 1 (Ref) | | |
| Female | 1.93 | 1.50–2.48 | <0.001 | 1.19 | 0.90–1.58 | 0.212 |
| **Population group** | | | | | | |
| Jews | 1 (Ref) | | | 1 (Ref) | | |
| Arabs | 1.80 | 1.34–2.41 | <0.001 | 1.61 | 1.20–2.16 | 0.002 |
| **Level of religiosity**[c] | | | | | | |
| Secular/Traditional | 1 (Ref) | | | 1 (Ref) | | |
| Religious | 1.15 | 0.83–1.59 | 0.406 | 1.94 | 1.41–2.67 | <0.001 |
| Ultra-Orthodox/Religiously devout | 1.17 | 0.73–1.89 | 0.512 | 3.23 | 2.03–5.15 | <0.001 |
| **Years of education** | | | | | | |
| >12 | 1 (Ref) | | | 1 (Ref) | | |
| ≤12 | 1.40 | 1.06–1.84 | 0.018 | 1.49 | 1.12–1.98 | 0.007 |
| **Marital status**[c] | | | | | | |
| Married or living with a partner | – | – | – | 1(Ref) | | |
| Separated or widowed | | | | 1.45 | 0.90–2.34 | 0.123 |
| Single | | | | 0.86 | 0.40–1.85 | 0.703 |
| **Parity**[c] | | | | | | |
| Having children | – | – | – | 1 (Ref) | | |
| Nulliparous | | | | 1.39 | 0.69–2.81 | 0.357 |
| **Ever diagnosed with COVID-19** | | | | | | |
| No | 1 (Ref) | | | 1 (Ref) | | |
| Yes | 0.92 | 0.50–1.68 | 0.787 | 1.69 | 1.16–2.45 | 0.006 |
| **Chronically ill**[c] | | | | | | |
| No | – | – | – | 1 (Ref) | | |
| Yes | | | | 1.16 | 0.84–1.60 | 0.371 |
| **Vaccinated for Influenza last winter (2019–2020)** | | | | | | |
| Yes | 1 (Ref) | | | 1 (Ref) | | |
| No | 1.88 | 1.45–2.43 | <0.001 | 2.11 | 1.53–2.89 | <0.001 |

CI = confidence interval; OR = odds ratio.
[a] "Intended or actual vaccinated for influenza in current winter (2020–2021)" was omitted from the model because of a strong correlation with "Vaccinated for Influenza last winter (2019–2020)".
[b] Used as a continuous variable.
[c] Not statistically significant at $\alpha < 0.1$ in the univariable analysis (before vaccine availability).

ulation and characterized those who remained with VH by sociodemographic and health-related factors and by reasons for VH. According to this survey, the majority (72.0 %) of Israeli adults were willing to be vaccinated against COVID-19. The findings also show a significant decline in VH after the vaccines were available to the public (from 45.6 % to 16.3 %). The reported acceptance of the COVID-19 vaccines in this study is in line with the total vaccination status of the Israeli adult population. As of June 2021, about 80.0 % of Israel's adult population had been fully vaccinated (i.e. two doses administrated at least three weeks apart) [13].

The 3C's model of the SAGE working group suggests that VH depends on three factors: convenience, complacency, and confidence [2]. The significant decrease in COVID-19 VH during the study's two phases can be explained by this model. Convenience results from the availability and affordability of the vaccine [1]. This survey demonstrated that the adjusted odds of COVID-19 VH before vaccine availability was six times higher than after it became available. Although initially, vaccines were prioritized for high-risk individuals (i.e. people aged 60 and over, nursing home residents, healthcare workers, and people with certain medical conditions) [12,14], by the beginning of February 2021, all individuals aged 16 years and older were eligible to receive the vaccine. Furthermore, the vaccines were administrated to the population free of charge by the Health Care system and were equally distributed between different municipalities all over the country [15]. Vaccination appointments could have been scheduled by a wide diversity of means (including health-plan call centers, websites, and apps) and walk-ins were accepted as well [16]. Therefore, it can be assumed that convenience played a dominant role in reducing COVID-19 VH among Israeli citizens.

Complacency reflects the perceived risk of becoming ill with the disease. According to this survey, as the COVID-19 pandemic progressed, VH decreased, and with it the percentage of participants who attributed their VH to lack of severity of the disease. Furthermore, only 5.0 % of VH participants reasoned their hesitancy to disbelief that they will get sick. Shmueli et al. [17] also demonstrated that higher levels of perceived severity of COVID-19 infection and higher perceived benefits of COVID-19 vaccine were associated with lower COVID-19 VH.

Confidence reflects one's trust in the effectiveness and safety of the vaccine, the perceived reliability of the health system that delivers the vaccine, and the trust in policy-makers who decide on the need for the vaccines [1,2]. In Israel, certain communities may already have lower trust in government institutions, including the Arab minority population, the ultra-orthodox sector, and low socioeconomic status communities [18]. The vaccination campaign in Israel tried to gain public trust through the utilization of an integrated and familiar health care system, transparency regarding vaccine safety information, use of culturally appropriate messages in digital and offline media, and active participation and role-modeling by political or religious opinion leaders [19]. An important part of this effort included monitoring social media for anti-vax messages and addressing them head-on [16]. Notably, the reduction in COVID-19 VH in this study was accompanied by a significant reduction in reporting that insufficient data on the vaccine was a reason for VH. Additionally, only 12.0 % declared that at least

**Table 3**
Adjusted[a] odds ratios (ORs) for the associations between vaccine hesitancy and participants' characteristics for the whole study period.

| Variable | Total study period | | |
|---|---|---|---|
| | OR | CI 95% | P value |
| **Survey period** | | | |
| Before vaccine availability | 1 (Ref) | | |
| After vaccine availability | 0.16 | 0.13–0.20 | <0.001 |
| **Age**[b] | 0.99 | 0.99–1.00 | 0.053 |
| **Gender** | | | |
| Male | 1 (Ref) | | |
| Female | 1.52 | 1.26–1.83 | <0.001 |
| **Population group** | | | |
| Jews | 1 (Ref) | | |
| Arabs | 1.58 | 1.29–1.94 | <0.001 |
| **Level of religiosity** | | | |
| Secular/Traditional | 1 (Ref) | | |
| Religious | 1.46 | 1.16–1.83 | 0.001 |
| Ultra-Orthodox/Religiously devout | 1.90 | 1.35–2.68 | <0.001 |
| **Years of education** | | | |
| >12 | 1 (Ref) | | |
| ≤12 | 1.47 | 1.21–1.79 | <0.001 |
| **Ever diagnosed with COVID-19** | | | |
| No | 1 (Ref) | | |
| Yes | 1.52 | 1.10–2.10 | 0.011 |
| **Chronically ill** | | | |
| No | 1 (Ref) | | |
| Yes | 1.07 | 0.87–1.33 | 0.508 |
| **Vaccinated for Influenza last winter (2019–2020)** | | | |
| Yes | 1 (Ref) | | |
| No | 1.92 | 1.57–2.34 | <0.001 |

CI = confidence interval; OR = odds ratio;
[a] "Intended or actual vaccinated for influenza in current winter (2020–2021)" was omitted from the model because of a strong correlation with "Vaccinated for Influenza last winter (2019–2020)".
[b] Used as a continuous variable.

**Table 4**
Reasons for vaccine hesitancy by survey period, September 2020 – May 2021.

| Reasons for vaccine hesitancy | Total period (%) (N = 596) | Before vaccine availability 8th Sept – 19th Dec 2020 (%) (N = 374) | After vaccine availability 20th Dec 2020 – 9th May 2021 (%) (N = 222) | P value |
|---|---|---|---|---|
| **There is insufficient data on the vaccine** | 48.0 | 54.3 | 37.4 | <0.001 |
| **I am afraid of the vaccine's side effects** | 29.0 | 26.2 | 33.8 | 0.049 |
| **I don't think the vaccine will be effective** | 12.7 | 13.4 | 11.7 | 0.558 |
| **I have been diagnosed with COVID-19 and therefore most probably immune** | 7.2 | 2.7 | 14.9 | <0.001 |
| **COVID-19 is not a dangerous disease (no need to be vaccinated)** | 6.9 | 8.8 | 3.6 | 0.015 |
| **I am healthy/ I am cautious and therefore I don't think I will get sick** | 5.4 | 5.6 | 5.0 | 0.730 |
| **Other reasons (including medical, religious or political reasons, disbelief in COVID-19 or in vaccines in general)** | 4.9 | 2.7 | 8.6 | 0.001 |

one of their reasons for VH was distrust in the effectiveness of the vaccine. Nevertheless, after vaccine availability, insufficient data was still the primary reason for VH, and a rise in fear of side effects was reported, as well as a rise in other reasons for VH, including medical, religious, or political reasons, and disbelief in COVID-19 or vaccines in general. All these issues should be further addressed to lower the VH further. Additional efforts to lower VH should also take into account the sociodemographic and health-related factors that were shown to be associated with COVID-19 VH. These factors, that were also demonstrated in other studies, include younger age [8], female gender [8,17,20], Arab ethnicity [20,21], higher level of religiosity [21,22], lower education [5,8,17,20] and influenza VH [17,23,24].

This study has several limitations. First, it has a cross-sectional design that does not enable determining causal relations between COVID-19 VH and associated factors. Second, data collected were self-reported and subject to recall bias and social desirability bias. Third, during the period of the survey, only the Pfizer-BioNTech vaccine was given to the public. The strength of this study, on the other hand, is that it was based on a national survey that included a representative sample of respondents from the two main population groups in Israel.

## 5. Conclusions

Although the vaccination campaign in Israel was very effective in reducing COVID-19 VH, there is still a relatively small but persistent percentage of the adult population that has yet to be vaccinated. As Israel may face additional COVID-19 pandemic waves and booster vaccinations may be further needed, it is essential to understand the barriers to achieving 100 % vaccination in hesitant populations and address them. The development of risk communi-

cation strategies and psychosocial research aimed at understanding people's perspectives on vaccination behaviors are needed.

## Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## Data availability

Data will be made available on request.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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