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Vaccine Intention, Uptake, and Hesitancy Among US Certified Food Producers: The National COVID-19 Organic Farmer Study

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Abstract

Objective: To estimate COVID-19 vaccine intention, uptake, and hesitancy among essential workers.
Methods: A cross-sectional survey of USDA-certified organic producers. An electronic survey was used for data collection. Analyses included descriptive statistics, χ^2 tests, and ordinal logistic regressions.
Results: The dataset consisted of 273 records. While 63% of respondents had received at least 1 dose of COVID-19 vaccine, only 17% had the recommended minimum of 2 doses. More than two-thirds of unvaccinated individuals indicated no plan to receive the vaccine, and limited perception of vaccine necessity. They indicated concerns about side effects and a distrust of the vaccines and the government. Age, education level, acreage, region, and health insurance status were variables significantly associated with the number of doses of vaccine received.
Conclusions: Interventions to encourage vaccination may target farmers who are less educated, live alone or just with one other person, lack health insurance, and run larger farms. Results also suggest focusing on enhancing trust in science and the government. Theory-based approaches that address low perception of risk and severity may be more likely to be effective with this population. Information on how US organic producers handled the COVID-19 pandemic is critical for emergency preparedness and food system stability.

Vaccines are instrumental in the eradication and control of infectious diseases. However, the recent COVID-19 pandemic emphasized the importance of a more coordinated and effective vaccine campaign. The World Health Organization (WHO) declared coronavirus disease 2019 a pandemic in March 2020,[1] and the United States (US) Food and Drugs Administration (FDA) gave emergency use authorization to the first COVID-19 vaccine in December of that year.[2] Vaccination and good hygiene habits were suggested to protect against COVID-19 and control the pandemic. However, hesitancy became a challenge to vaccination efforts. Despite overwhelming evidence of vaccine effectiveness and widespread availability, population-level acceptance of the COVID-19 vaccines constituted a barrier to emergency and public health efforts. Global data showed high rates of hesitancy to receiving the vaccines before and after official approval, even through mid-2022.[3–7]

In the US, vaccine acceptance rates during pre- and post-authorization varied across studies and population groups, from 25% to 80%.[4,8–17] Early 2020 data showed that only about 60% of adults intended to obtain the vaccine once available,[18] and that vaccination rates were unlikely to achieve herd immunity.[19] By mid-2021 nearly 55% of the US population had been vaccinated with at least 1 dose of a COVID-19 vaccine, but only 47% were fully vaccinated (2 or more doses).[20] Furthermore, disparities in vaccination rates persisted across certain population groups and geographical areas.[19,21–24]

Public health efforts intensified, and a 2022 global survey indicated that people in the US had more confidence in vaccines compared to those in other countries. The study also found that 75% of people felt that vaccines were safe and effective.[25] By November 2023, 80% of the US population had received at least 1 dose of the COVID-19 vaccine, but approximately 30% were not fully vaccinated with 2 doses or equivalent.[26] This is significant as there is evidence that vaccination reduces symptoms, severity, and duration of COVID-19 infection.[27–29] The SARS-CoV-2 virus is still active and new variants continue to emerge in 2024 (e.g., KP.2 variant).

Vaccine hesitancy, the delay in acceptance or refusal of vaccination despite availability of vaccination services,[30] constitutes a significant barrier to immunization campaigns in the US.[31] There is extensive literature on vaccine hesitancy, with researchers agreeing that is a complex issue determined by multilevel individual, interpersonal, social, and other contextual factors.[32–34] They also emphasize the difficulties in properly addressing vaccine hesitancy.[35,36]

There is also a significant body of literature on COVID-19 vaccine hesitancy, intention, and uptake among US essential workers, such as first responders and health care providers.[37–49]

However, "essential worker" is a comprehensive category that encompasses workers in various industries, including food and agriculture,[50] which is essential to food availability.

After the onset of the COVID-19 pandemic, it was evident that the entire food chain was severely disrupted.[51,52] Meanwhile, the demand for agricultural produce increased.[53,54] Upon returning to work, farmworkers faced an elevated risk of virus exposure, especially since manual tasks like harvesting and packing made it challenging for them to adhere to social distancing and basic prevention recommendations.[55–57] While disparities in vaccination coverage has been an ongoing public health challenge,[58–61] identifying the populations that are affected and the factors that contribute to it is essential for emergency preparedness and infection control. Studies have found that COVID-19 infection and fatality rates are associated with sociodemographic, structural, and environmental risk factors.[62,63] There is also strong evidence that the impact of COVID-19 has been different across the food production system. Therefore, there is consensus on the importance of identifying which subgroups of agricultural workers are more susceptible to the negative effects of current and future pandemics and risks.[64–68]

The Organic Producer and COVID-19

An increasingly important contributor to food production is the organic farmer. According to the US Department of Agriculture (USDA), there are more than 27,700 certified organic farms in the US.[69] However, the number of small farms growing food without synthetic inputs and offering pesticide-free produce through local markets is unknown but much larger. Data show that organic foods are available in practically every conventional US grocery store.[70]

The COVID-19 pandemic triggered a disruption in the global food supply chain. As a consequence, consumers' reliance on small organic farmers increased. Sales of organic produce significantly grew during the pandemic: total sales in organic products reached $11.2 billion in 2021, a 13% increase from 2019.[71] Thus, organic producers showed to be essential to food availability and access during the COVID-19 pandemic. Furthermore, since most organic farms are small and local, it has been suggested that they contribute to resilience and are essential for communities to overcome and recover from disruption.[72]

Whether the experience of the US organic farmer with COVID-19 may differ from that of the general population or the overall farmworker is unclear, as only limited research on the topic has emerged.[65–67] Additionally, we should not assume that existing agricultural surveillance data and reported research findings necessarily apply to the organic farmer. Some studies in the US found differences between the conventional and the organic farmer, particularly in sociodemographic characteristics, and farming experience and production practices.[73–75] These differences may have implications for public health preparedness, and for how organic farmers respond to future pandemics and vaccination efforts.

Because increasing demand for organic products and the key role organic farmers played in food availability and access during the COVID-19 pandemic, it is imperative to understand how the organic producer dealt with the pandemic and how this essential workforce responded to prevention and vaccination recommendations.

National COVID-19 Organic Farmer Study

The National COVID-19 Organic Farmer Study collected data from US certified organic producers between 2020 and 2022. The overall purpose was to assess the impact of COVID-19 on the organic farmer. The study was conducted at the University of New Mexico College of Population Health and funded by the National Institute for Occupational Safety and Health and the Southwest Center for Agricultural Health, Injury Prevention, and Education (SW Ag Center) at the University of Texas Health Sciences Center at Tyler.

Results on the 2020-2021 COVID-19 data have been previously reported, including prevalence and prevention behaviors,[65] health care delays,[66] and overall impact on the farmer and farming community.[67] This article reports on 2022 data related to vaccine intention, uptake, and hesitancy. The information is essential for emergency preparedness, to protect the organic producers, and to improve the resilience of the food supply chain.

Methods

This research consisted of a cross-sectional survey of USDA certified organic producers conducted in spring-summer 2022, after the COVID-19 vaccine was widely available to US adults. The study was approved by the Institutional Review Board at the University of New Mexico Health Sciences Center.

Participants and Recruitment

Participants included producers listed in the USDA Organic Integrity Database (OID). The USDA defines the farm producer as "the person who runs the farm, making day-to-day management decisions for the farm operation. She/he may be the owner, a member of the owner's household, a hired manager, a tenant, a renter, or a sharecropper."[76] The OID is a publicly available database of international certified organic operations. It includes a variety of operations (i.e., crop, handling, livestock, and wild crops) and certification status (i.e., surrendered, suspended, revoked, and other). Contact information consists of name (producer), phone, email, website, and physical and mailing address. Email address is not a mandatory field, and only a portion of listed operations include one. Qualifying criteria for this study included: (1) 18 years of age or older, (2) currently operating an organic farm in the US, including crop, livestock, and wild crops, and (3) listing a valid email address in the OID. Excluded were operations that solely engaged in handling and processing organic consumer products.

An initial OID advanced search resulted in 5102 records listing unduplicated emails. In early January, an invitation message was sent to all identified addresses. The message included information on the study and informed consent, and a link to the electronic survey.

The study was promoted through the researchers' institutional websites, social media outlets, and parties such as extension agents and farm organizations. Scheduled reminder emails were sent to non-respondents until the end of June. Participation incentive consisted of entering a raffle for a chance to win one of forty $50 merchandise cards from a national hardware and home improvement store.

Data Collection

Data were collected through a survey developed by the research team. The development process included a search of the literature on the COVID-19 vaccine, and a review and adoption of domains and items from national COVID-19 ongoing surveys, such as the

Centers for Disease Control and Prevention (CDC) National Immunization Survey (NIS)-Adult COVID Module (NIS-ACM), which assessed COVID-19 vaccination coverage in adults 18 years and older; the Household Pulse Survey, by the US Census Bureau, which measured household experiences during the coronavirus pandemic, and other vaccine administration data reported to the US Department of Health and Human Services (HHS) and CDC through the COVID Data Tracker. Reiterated versions were developed and revisited and a final draft was reviewed by experts in public health, social and behavioral sciences, epidemiology, occupational health, and an agricultural researcher. It consisted of a standard sociodemographic section and COVID-19 related domains on health and prevention behavior, health care access, personal and community impact, and a 9-item section on vaccination. Response options consisted of binary yes/no, Likert-type, and other scales measuring quality, agreement, and frequency. The estimated completion time was approximately 10 minutes. Those who accessed the survey were first asked to confirm the qualifying criteria and to voluntarily agree to participate. A link to review and download the informed consent was also provided.

Data Management and Analysis

The online survey was hosted on Research Electronic Data Capture (REDCap), which is a secure web application for online survey building and management. Of the 5102 farmers who were invited, 273 accessed the survey (estimated response rate: 5.4%). Of those, 20 either did not qualify (indicated they were not USDA-certified organic farmers, or not currently operating a farm) or did not answer these items and were excluded from the analysis. SPSS (IBM SPSS Statistics, Armonk, NY: IBM Corp) and R (*MASS* and *mice* packages) were used for data analysis.

Descriptive statistics were conducted on key variables of interest, including sociodemographic and farm characteristics, health insurance, and self-reported COVID-19 infection and vaccine status (see Table 1 and Table 2). Overall, only 34 cases were incomplete (had missing values in any of the key variables). Chi-square (χ^2) tests were performed to assess differences between complete and incomplete cases. Missingness was associated with participants' health insurance status, and those without health insurance were more likely not to finish the survey compared to participants who had any type of health insurance ($P < 0.003$). Therefore, the amount of missing data was moderate (13.4% of the sample), and the completers and incompleters were only significantly different on the variable of health insurance.

In terms of key variables of interest, COVID-19 vaccine acceptance was defined as having received at least 1 dose of a COVID-19 vaccine, and if not, willingness to take the COVID-19 vaccine when available. Vaccine hesitancy was assessed among those who answered "no" to the question of whether they had received at least 1 dose of a COVID-19 vaccine; it was defined as selecting "unsure/no opinion," "somewhat disagree," or "strongly disagree" to the question of whether they would take a COVID-19 vaccine when available.

A more comprehensive analysis was conducted using doses of the COVID-19 vaccine received as the dependent variable, which was an ordinal variable with 5 categories ranging from 0 to 4 doses. The following categorical criteria were applied: 1 dose or more indicates COVID vaccination acceptance; 2 received the recommended 2 shots; 3 or more booster shots beyond the minimum recommended 2 shots. Two ordinal logistic regressions were conducted to assess the association between COVID-19 vaccine doses received and participants' sociodemographic and farm characteristics, as well as health insurance status and prevalence of COVID-19 infection. For the first model, an ordinal logistic regression with listwise deletion was conducted. A multiple imputation based on chain equation (MICE) was also implemented to address the missing data for the identified key variables. MICE produces unbiased estimates for missing at random (MAR) data. A second pooled ordinal logistic regression was then conducted combining models fitted on the imputed data sets.

Results

The electronic data file consisted of 253 valid records. The sample included producers from 33 states; with higher representation from New York (n = 34, 13.4%), Maine (n = 23, 9.1%), and New Mexico (n = 17, 6.7%). California, Colorado, Illinois, Michigan, Nebraska, Ohio, Pennsylvania, and Texas were states representing 4% to 5.5% of the sample.

Table 1 presents the sociodemographic and farm characteristics of the sample, the distribution of respondents by geographic region, and self-reported data on health insurance status and COVID-19 prevalence. A majority of participants were older than 55 years (55.3%), non-female (53.0%), white (74.3%), educated with a college degree or above (56.1%), US-born (81.4%), married (71.5%), and experienced farmers (50.6%). A very high majority (83.0%) had some type of insurance; nearly 40% of participants or a member of their households had experienced COVID-19 infection themselves.

Table 2 presents data on vaccination status and intention. Nearly 63% of respondents reported having received the COVID-19 vaccine, and 17% of those had the recommended minimum of 2 doses; more than one-third had received 3 doses, and a portion of them (5.1%) had received 4 doses. However, nearly one-fourth of respondents had not received a COVID-19 vaccine at the time of the survey. Among them, more than two-thirds indicated no plan to get it.

Answers to reasons for not getting a COVID-19 vaccine varied, but a majority indicated concerns about side effects, and trust in the actual vaccines and the government. Perception of the need for the vaccine, threat of infection, and vaccine effectiveness were also frequent responses.

Table 3 shows the results of the first ordinal logistic regression model. Age, education level, acreage, region, and health insurance status were the variables significantly associated with the doses of COVID-19 vaccine received after adjusting for other variables. Comparing age groups (under 55 years of age vs. 55 years of age or older), the odds of receiving 1 vaccine dose or more was 2.41 (95% CI: 1.18 – 5.00) times greater among the older group. As expected, education level played a significant role in vaccine acceptance. Participants who had a 4-year degree or higher were 2.50 (95% CI: 1.33 – 4.76) times more likely to have received 1 or more doses of the COVID-19 vaccine compared with those who had less than a 4-year degree. Farm size also had an impact: those managing a farm of at least 50 acres were 73% (OR = 0.27; 95% CI: 0.13 – 0.54) less likely to have received 1 or more doses of the COVID-19 vaccine; so did health insurance: the odds of receiving 1 or more doses of the COVID-19 vaccine in organic farmers who had any type of health insurance were 3.35 times higher than the organic farmers who did not have any health insurance (OR = 3.35; 95% CI: 1.33 – 8.81). In terms of geographic location, farmers who lived in southern states (e.g., Alabama, Arkansas, Texas, Florida, Georgia, Kentucky) were 2.48 times more likely to have received 1 or more doses of the

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Table 1. Sociodemographic and farm characteristics, and health insurance and COVID-19 status

Variable	N	(%)
Age		
Under 55 years of age	77	30.4%
55 years of age or older	140	55.3%
Missing	36	14.2%
Gender		
Female	81	32.0%
Not female	134	53.0%
Missing	38	15.0%
Race/ethnicity		
White/caucasian	188	74.3%
Other	30	11.9%
Missing	35	13.8%
Education level		
Less than 4-year degree	76	30.0%
4-year degree or more	142	56.1%
Missing	35	13.8%
Place of birth		
USA	206	81.4%
Outside of USA	9	3.6%
Missing	38	15.0%
Annual household income		
Under $50,000	46	18.2%
$50,000 or more	158	62.5%
Missing	49	19.4%
Household size		
Lives alone or with 1 other person	109	43.1%
2 or more other people	108	42.7%
Missing	36	14.2%
Marital status		
Not married or cohabitating	36	14.2%
Married or cohabitating	181	71.5%
Missing	36	14.2%
Years in organic agriculture		
Fewer than 10 years	89	35.2%
More than 10 years	128	50.6%
Missing	36	14.2%
Type of farms		
Crops/wild crops	189	74.7%
Livestock	12	4.7%
Both	46	18.2%
Missing	6	2.4%
Acreage		
Fewer than 50 acres	93	36.8%
At least 50 acres	120	47.4%
Missing	40	15.8%
Regions		
Northeast	77	30.4%
Midwest	76	30.0%
South	42	16.6%
West	58	22.9%
Health insurance status		
No health insurance	37	14.6%
Any type of health insurance	210	83.0%
Missing	6	2.4%
Respondent and/or household member had COVID–19		
Myself	24	9.5%
Someone in my household	29	11.5%
Both myself and at least one other person in my household	43	17.0%
No one has been confirmed with COVID–19	152	60.1%
Missing	5	2.0%

COVID-19 vaccine (OR = 2.48; 95% CI: 1.02 – 6.11) compared with those who lived in northeastern states (e.g., Maine, New Hampshire, Vermont, Massachusetts).

Finally, the likelihood of receiving additional doses of the COVID-19 vaccine gradually increased with dosage. For instance, the expected odds ratio of receiving a third dose was 7.33 (95% CI: 1.83 – 29.28) times higher than the expected odds of receiving only 2 doses; and the expected odds ratio of receiving 4 doses was 262.07 (OR = 262.07; 95% CI: 52.66 – 1304.25) times higher than that of receiving 3 doses. The Brant test of parallel regression assumption

Table 2. Self-reported COVID-19 vaccination status and intention

Variable	N	(%)
COVID–19 vaccination rate		
Not vaccinated	61	24.1%
Vaccinated	158	62.5%
Missing	34	13.4%
Dose(s) of COVID–19 vaccine among vaccinated participants		
0	61	24.1%
1	8	3.2%
2	43	17.0%
3	93	36.8%
4 or more	13	5.1%
Not sure/don't know	1	0.4%
Missing	34	13.4%
Vaccination plan for those who have not received vaccine		
Definitely get a vaccine	1	1.6%
Probably get a vaccine	1	1.6%
Be unsure about getting a vaccine	2	3.3%
Probably not get a vaccine	12	19.7%
Definitely not get a vaccine	45	73.8%

Table 3. Ordinal logistic regression analysis[a] to examine the relationship between dose(s) of COVID-19 vaccine received, and sociodemographic and farm characteristics and health insurance and COVID-19 status (list-wise deletion)

Variable	OR (95% CI)	*P* value
Age		
	Under 55 years of age[b]	
55 years of age or older	**2.41 (1.18, 5.00)**	**0.017**
Gender		
Female[b]		
Not female	0.94 (0.49, 1.82)	0.849
Race/ethnicity		
White/caucasian[b]		
Other	0.75 (0.30, 1.84)	0.529
Education level		
Less than 4-year degree[b]		
4-year degree or more	**2.50 (1.33, 4.76)**	**<0.01**
Annual household income		
Under $50,000[b]		
$50,000 or more	1.07 (0.49, 2.34)	0.857
Household size		
Lives alone or with 1 other person[b]		
2 or more other people	0.71 (0.36, 1.39)	0.319
Marital status		
Not married or cohabitating[b]		
Married or cohabitating	1.32 (0.57, 3.07)	0.514
Years in organic agriculture		
Fewer than 10 years[b]		
More than 10 years	1.46 (0.78, 2.73)	0.237
Type of farms		
Crops/wild crops[b]		
Livestock	0.55 (0.15, 1.89)	0.342
Both	1.24 (0.57, 2.71)	0.589
Acreage		
Fewer than 50 acres[b]		
At Least 50 acres	**0.27 (0.13, 0.54)**	**<0.001**
Regions		
Northeast[b]		
Midwest	0.81 (0.37, 1.79)	0.598
South	**2.48 (1.02, 6.11)**	**0.046**
West	1.91 (0.83, 4.48)	0.133
Health insurance status		
No health insurance[b]		
Any type of health insurance	**3.35 (1.33, 8.81)**	**0.012**
Respondent and/or household member had COVID–19		
No[b]		
Yes	0.73 (0.38, 1.41)	0.344

(*Continued*)

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Table 3. (*Continued*)

Variable	OR (95% CI)	*P* value
Intercepts		
0|1	1.75 (0.45, 6.83)	0.424
1|2	2.27 (0.58, 8.86)	0.238
2|3	**7.33 (1.83, 29.28)**	**<0.01**
3|4	**262.07 (52.66, 1304.25)**	**<0.001**

OR, Odds Ratio; CI, Confidence Interval
Boldface indicates statistical significance ($P < 0.05$).
[a]Proportional odds assumption upheld.
[b]Reference group

yielded $\chi^2 = 57.23$ ($P = 0.17$), indicating that the proportional odds assumptions of the first ordinal logistic regression were upheld.

Results from the pooled ordinal logistic regression (Table 4) showed an association between doses of COVID-19 vaccine received and age, education level, and farm size. Those who were 55 years of age or older (OR = 2.90; 95% CI: 1.42 – 5.95; $P < 0.01$), more educated (OR = 2.91; 95% CI: 1.49 – 5.68; $P < 0.01$), and ran smaller farms (OR = 3.97; 95% CI: 2.10 – 7.52; $P < 0.001$) were more likely to report that they had received a vaccine. Results also confirmed that the likelihood of receiving additional doses of the COVID-19 vaccine gradually increased with dosage (see Table 4). However, the Brant tests of parallel regression assumptions showed that some of the proportional odds assumptions in the individual imputed data did not hold. This heterogeneity of the validity of the proportional odds assumption indicates that there was additional variability caused by missing data. However, the inferences on the effects from all models fitted using imputed data have no categorical differences. The inferences from the list-wise deletion based ordinal regression model and the pooled ordinal regression model from MICE imputations do not show categorical differences in terms of identified factors significantly associated with COVID-19 vaccination.

Limitations

To our knowledge, this is the first study exploring and reporting COVID-19 vaccine issues among US certified organic producers. Despite its limitations, the study may inform future research and practice. The sample was limited to those who listed an email address in the USDA OID, received an invitation, had internet access, and completed the electronic survey. Thus, the sample may not properly represent the population of interest. The response was low, although participants represented farmers from 33 out of 50 US states. Furthermore, some demographic and farm characteristics of respondents are consistent with national data on overall farmers and organic producers. Another factor to keep in mind is that although all models showed consistency in terms of inferences on the effect, there was variability on the proportional odds assumption, which may be caused by missing data. This was a cross-sectional survey study and data were only collected in the first half of 2022, which does not reflect longitudinal trends. Additionally, results may have changed as more information on the safety and availability of COVID-19 vaccines later became available. Finally, although data were self-reported and may reflect respondents' personal biases, self-reported questionnaires are widely used and validated in observational studies.

Discussion

While food producers, including organic farmers, are essential workers and were a key workforce during the recent COVID-19 pandemic, research and literature on this population is scarce. The National COVID-19 Organic Farmer Study explored vaccination issues among USDA certified organic producers, including intention and hesitancy. This information is essential to understand how these farmers dealt with the pandemic, their response to prevention recommendations, and their emergency preparedness.

The number of organic producers is still small, but considering the importance of local food systems, the added risk confronted by farmers, and the essential role of the farming workforce during the COVID-19 pandemic, additional resources should be dedicated to vaccine information and education in this population. This is not only important for emergency preparedness, but also for post-pandemic recovery. Researchers suggest that local food systems and farmers are key to helping communities recover from crises.[72]

Respondents included farmers from all 4 regions of the US. On the characteristics of the sample, of notice is that more than one-third of participants were younger than 55 years of age. While the average age of the farm producer is 57.5 years, and the US farming population continues a long trend of aging,[77] data show that farm operators are younger in the organic sector than in the overall agriculture sector.[78]

The self-reported vaccination rate was 72%, and 67% of respondents were fully vaccinated (had received the recommended 2 doses). These results are consistent with national COVID-19 data. US Coronavirus Vaccine Tracker (https://usafacts.org/visualizations/covid-vaccine-tracker-states/) shows vaccine rates between January and June 2022 (the data collection phase for the present study) at 74%-78% of the population with at least 1 dose, and 62%-67% fully vaccinated. While these rates maintained relatively constant throughout mid-2023 in the general population,[79] this may not apply to agricultural workers. Studies found that farmworkers faced challenges with health care access and testing mandates,[66,67,80,81] and a 2021 mid-year study with Latino farmers in Florida reported a 46% vaccination rate.[82]

Regarding vaccine intention, more than 93% of unvaccinated participants reported little or no interest in getting the COVID-19 vaccine and mentioned concerns related to side effects and trust. This result was not surprising. Concerns about the side effects of COVID-19 vaccines were identified as an issue of public concern throughout the pandemic across populations, including farmers and other essential workers.[82–85] Similarly, public trust is a critical issue that always arises during health emergencies, as it affects compliance with recommendations and mandates and determines

Table 4. Pooled ordinal logistic regression analysis[a] to examine the relationship between dose(s) of COVID-19 vaccine received and sociodemographic and farm characteristics and health insurance and COVID-19 status (multiple imputation)

Variable	OR (95% CI)	*P* value
Age		
Under 55 years of age[b]		
55 years of age or older	**2.90 (1.42, 5.95)**	**<0.01**
Gender		
Female[b]		
Not female	1.01 (0.51, 2.00)	0.982
Race/ethnicity		
White/caucasian[b]		
Other	0.77 (0.29, 2.04)	0.590
Education level		
Less than 4-year degree[b]		
4-year degree or more	**2.91 (1.49, 5.68)**	**<0.01**
Annual household income		
Under $50,000[b]		
$50,000 or More	0.90 (0.38, 2.14)	0.808
Household size		
Lives alone or with 1 other person[b]		
2 or more other people	0.83 (0.36, 1.87)	0.631
Marital status		
Not married or cohabitating[b]		
Married or cohabitating	1.85 (0.72, 4.77)	0.191
Years in organic agriculture		
Fewer than 10 years[b]		
More than 10 years	1.47 (0.77, 2.81)	0.236
Type of farms		
Crops/wild crops[b]		
Livestock	0.63 (0.17, 2.35)	0.490
Both	1.09 (0.50, 2.37)	0.830
Acreage		
Fewer than 50 acres[b]		
At Least 50 acres	**0.25 (0.13, 0.48)**	**<0.001**
Regions		
Northeast[b]		
Midwest	0.89 (0.42, 1.90)	0.770
South	2.22 (1.00, 4.93)	0.051
West	1.96 (0.69, 5.58)	0.194
Health insurance status		
No health insurance[b]		
Any type of health insurance	1.94 (0.87, 4.33)	0.106
Respondent and/or household member had COVID–19		
No[b]		
Yes	0.69 (0.35, 1.37)	0.282

(*Continued*)

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Table 4. (*Continued*)

Variable	OR (95% CI)	*P* value
Intercepts		
0|1	2.11 (0.58, 7.66)	0.250
1|2	2.64 (0.72, 9.65)	0.141
2|3	**7.10 (1.85, 27.27)**	**<0.01**
3|4	**187.20 (39.51, 886.91)**	**<0.001**

OR, Odds Ratio; CI, Confidence Interval
Boldface indicates statistical significance ($P < 0.05$).
[a]The proportional odds assumptions in some of the individual imputed ordinal logistic regression didn't uphold.
[b]Reference group

the effectiveness of the response. The COVID-19 pandemic was no exception. Trust in science and expertise across diverse population groups was brought up early during the vaccine development and approval processes.[15,19,86–89] Public trust in governments, health agencies, health care providers, and vaccine safety and effectiveness was related to compliance with COVID-19 mandates and vaccine intention in the US and globally.[89–91]

Low perception of the risk of getting SARS-CoV-2, the potential severity of the infection, and the protective efficacy of the vaccine were also frequently selected by participants as reasons for not getting the vaccine (Figure 1). These results may inform interventions to promote prevention and vaccination in this population. Other studies exploring the ongoing challenge of COVID-19 vaccine hesitancy have identified perception as a relevant construct and proposed theory-based strategies to address the issue.[92–94] A theory that has been proposed is the Health Belief Model (HBM), which highlights the role of perception in predicting behavior and behavioral intention. The HBM specifically refers to perception of susceptibility and severity, which along with perceived benefits and barriers to action may determine the likelihood of performing a health-related behavior.[95,96] Previous research on compliance during this and past infectious disease epidemics shows that individuals who have a high perception of the risks of being infected and experiencing negative health consequences are more likely to comply with government restrictions and public health guidelines.[97,98] Interventions that properly address the perception of risk and severity may be more likely to encourage vaccination in this population.

The analysis of geographic location yielded interesting results. Participants living in the South were more likely to receive the vaccine compared to those in the Northeast. This is inconsistent with federal data indicating higher vaccination rates in the northeast, including Maine, Vermont, Massachusetts, and Connecticut, compared to the southern region, particularly Mississippi, Louisiana, and Alabama (see the CDC's COVID Data Tracker at https://covid.cdc.gov/covid-data-tracker/#vaccinations_vacc-people-booster-percent-pop5). The result is interesting because of the polarization of the COVID-19 pandemic and vaccines in the US. While northeast states traditionally vote for the Democratic Party and are considered blue, southern states are more conservative and categorized as red. Some studies have looked at the politics of the COVID-19 vaccine.[99,100] Others explored the red/-blue divide in the COVID-19 vaccine and found lower vaccination rates in Republican-leaning states and counties that voted Republican.[101–103] Perhaps, this study's sample was not representative of political preferences and party affiliations. Future research may explore this finding further, as recent data show higher COVID-19-related death rates in states with Republican governors and state legislature representation compared to Democratic states. Researchers emphasize the need to prioritize evidence-based decision-making over political considerations.[104,105] Finally, results exploring factors that may contribute to vaccine uptake suggest that age, education level, acreage, region, and health insurance status may play a role in COVID-19 vaccination in this population. Older age, higher education level, smaller farms, and health insurance had a significant positive effect on the number of doses received. Most of

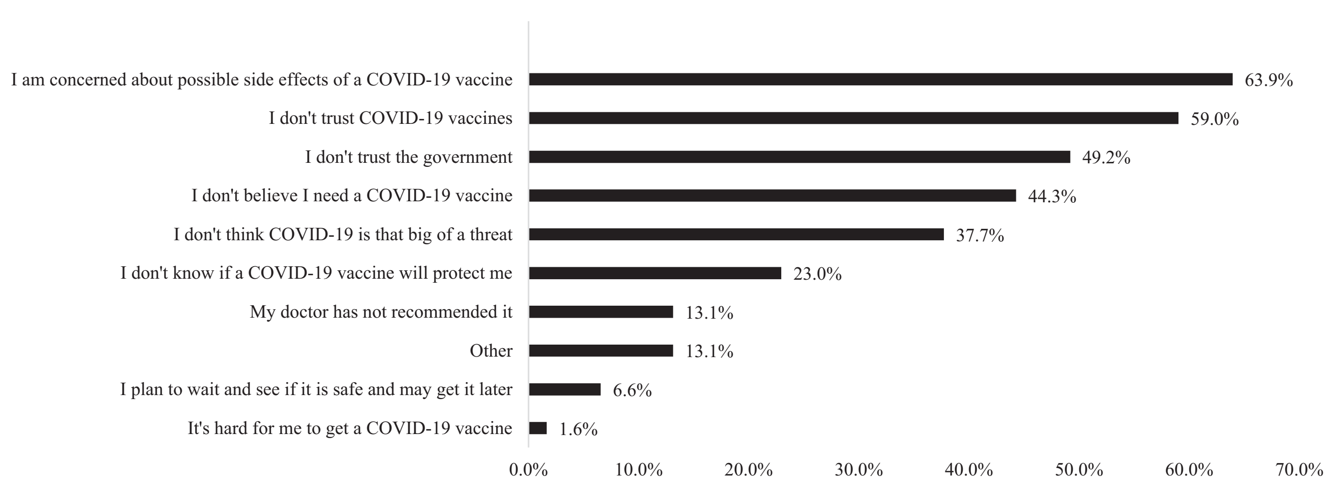

Figure 1 Reasons selected by unvaccinated participants for not receiving a COVID-19 vaccine, in percentage.

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these associations were confirmed by the ordinal logistic regression analysis. Previous studies in the US found positive associations between education level and health insurance and vaccine acceptance and hesitancy among the general adult population and certain population-specific groups, including essential workers.[106–113]

The present study identified multilevel factors that may determine vaccine intention and uptake in this particular population of essential workers. These include sociodemographic factors such as age, education level, acreage, region, and health insurance. Concerns about side effects and low perception of risk, and lack of trust in governments, health agencies, and authorities were also highlighted by participants. Identifying and measuring barriers to vaccine acceptance is a critical first step to properly address vaccine hesitancy and uptake. The literature recommends tailored communication, community outreach to engage with specific groups based on their characteristics and concerns, facilitated discussions that are more productive and less confrontational, and offering incentives that are relevant and attractive to the specific groups.[36,114,115] In practical terms, this means placing the organic producer at the center of the communication strategy (e.g., identifying a vaccine champion) and tailoring the messages to specific subgroups (e.g., younger, less educated, live alone, run larger farms in northwestern states, and hold more conservative political views). Focusing the communication on the vaccine development process, safety, and effectiveness could potentially enhance trust in science and the government. Theory-based approaches that address low perception of risk and severity may be more likely to be effective with this population.

Conclusions

Food producers are essential for food availability and access, and the organic farmer is an increasingly vital population within the agricultural workforce. Information on how US organic farmers dealt with the COVID-19 pandemic is critical for emergency preparedness, to protect these farmers from disease and illness, and to improve the resilience of the food supply chain.

The National COVID-19 Organic Farmer Study was launched in 2021 to follow USDA certified organic producers throughout the pandemic, including vaccination. The study identified key multilevel factors that contribute to vaccine acceptance and hesitancy in this population. The results may not only inform continuous efforts to address COVID-19 vaccination issues in this essential workforce, but also to be better prepare for future pandemics.

Data availability statement. The data that support the findings of this study are not openly available due to reasons of sensitivity and may be available from the corresponding author upon reasonable request.

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Author contribution. FSM: led study design and data collection; wrote first draft of manuscript and contributed to editing and final version. SZ: contributed to analysis plan, data analysis and interpretation, results narrative and editing. MJ: contributed to analysis plan, data analysis and interpretation and editing.

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Competing interest. The authors declare that there are no conflicts of interest to disclose. No commercial or proprietary interest to declare.

Ethical standard. The study was approved by the University of New Mexico Health Sciences Center IRB (Study # 20–534) and all participants were presented with the approved informed consent.

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