



Occupational disparities in COVID-19 vaccine hesitancy in Japan

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ABSTRACT

Background: We examined occupational disparities in COVID-19 vaccine hesitancy in Japan.

Methods: Cross-sectional online surveys were conducted among of residents living in Iwate Prefecture from July 2 to 4 and from October 1 to 3 in 2021 (total n=17,914). Intention to get vaccinated for COVID-19 was assessed by self-report questions. We calculated odds ratios for vaccine hesitancy among occupational groups using logistic regression models controlling for covariates and stratified by age and sex groups.

Results: The overall prevalence of vaccine hesitancy was 5.5% in our sample of working-age adults. Women <40 years were also 1.6 times more likely to be vaccine hesitant, citing concerns about adverse effects on pregnancy or breastfeeding. Among people aged 40–59 years, workers in the service industry, manufacturing industry, and the unemployed were significantly more likely to have perceived vaccine hesitancy regardless of sex. Young service workers viewed themselves as being more vulnerable to risk of infection but less susceptible to getting severe disease, whilst exhibiting low levels of vaccine knowledge. Middle-aged (40–59 years) workers in the manufacturing industry underestimated both vulnerability to infection and disease severity, as well as demonstrated low knowledge of vaccines and practice of preventive measures.

Conclusions: While complex and heterogeneous reasons for COVID-19 vaccine hesitancy have been cited in Western countries (e.g., mistrust of government, medical mistrust, and conspiracy beliefs), the situation in Japan may be more amenable to educational interventions targeting specific occupations. Policymakers should target interventions for increasing vaccine readiness in high risk occupations.

1. Introduction

Since mid-February 2021 when the Pfizer vaccine for COVID-19 was approved by the Japanese government, an estimated 80.7% of the population have received their first dose of the vaccine, 79.5% two doses, and 17.4% three doses (Burki, 2022). However, vaccine hesitancy poses a challenge in Japan, as it does elsewhere in the world. A global survey revealed that the prevalence of vaccine hesitancy varies by country, e.g., ranging from 22% to 31.1% in the United States (Callaghan et al., 2021; Khubchandani et al., 2021), to 19% in European countries (Neumann-Böhme et al., 2020). The prevalence of vaccine hesitancy in Japan has been reported to be much lower compared to

western countries – between 9.3% and 22.0% in Japan (Kadoya et al., 2021; Nomura et al., 2021; Okubo et al., 2021; Sugawara et al., 2021; Yoda & Katsuyama, 2021).

In western contexts, there is considerable heterogeneity in the reasons why people report COVID-19 hesitancy (Milošević Đorđević et al., 2021). Some individuals express persistent concerns about the safety of vaccines or their efficacy. In the United States, some groups express skepticism about the need for vaccines, and in extreme cases, consider COVID-19 to be a hoax. Other individuals object to mandatory vaccination as an infringement to their individual freedom to choose (to remain vaccinated). Yet other groups – such as African Americans – are hesitant for reasons of medical mistrust. Lastly, there is a group of people

Abbreviations: CI, confidence interval; OR, odds ratio.

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who resist vaccination because of conspiracy theories, or because of political beliefs. Importantly, the different segments of the population who are vaccine hesitant do not overlap. For example, in the United States, African Americans cite medical mistrust as a reason for their hesitancy, reflecting the history of mistreatment by the medical establishment (e.g., the Tuskegee experiment). However, this segment does not overlap with other individuals (e.g., white Republicans) who refuse the vaccine because they view COVID-19 as a hoax (Callaghan et al., 2021; Oliver, 2021; Philip, 2021). The segmentation of the vaccine hesitant population in the United States makes it extremely challenging to formulate a unified intervention to encourage vaccine uptake.

In terms of demographic background, vaccine hesitant groups vary by race/ethnicity, socioeconomic status (Joshi et al., 2021), political affiliation, geography, and so on in the world. Moreover, factors related to vaccine hesitancy vary from one country to another, depending on their historical, cultural, and policy context. For example, in the United States, a major reason for delaying COVID-19 vaccination has been traced back to the lack of paid sick leave, i.e., many people work in jobs where they cannot afford to take time off – or fear being laid off – if they are unable come to work due to the anticipated side effects of the vaccine. By contrast, this factor is not an issue in Japan where workers have sick leave. Lastly, there are individual differences in risk perception and perceived susceptibility to COVID-19 which affects readiness to accept the vaccine. For example, obesity (BMI >30 [m/kg²]) is associated with increased severity of SARS-CoV-2 infection in Japan (Saito et al., 2022), and the prevalence of obesity is higher among middle-age generations. Previous studies have found that women of reproductive age are less likely to get vaccinated, due to concerns about the side effects of vaccination on pregnancy and breastfeeding worldwide (Joshi et al., 2021; Khan et al., 2021; Machida et al., 2021; Nomura et al., 2021; Okubo et al., 2021; Robinson et al., 2021; Wake, 2021; Yoda & Katayama, 2021).

One of the theories for health behavior is the health belief model in which people protect themselves based on perceived susceptibility and/or severity of an illness (Health Belief Model) (Glanz et al., 2008). If people recognize their risks of exposure to the virus, they adopt disease prevention strategies such as receiving a vaccine. The risk of SARS-CoV-2 infection is stratified by occupation. For example, healthcare workers and workers in customer-facing industries (e.g., food & retail services) are at higher risk of infection, so that these occupations should receive high priority for vaccination. However, only a few previous studies have considered occupational disparities in vaccine hesitancy (King et al., 2021; Nomura et al., 2021). Accordingly, this study aimed to examine occupational segments associated with COVID-19 vaccine hesitancy in Japan.

2. Methods

2.1. Study population

Iwate Prefecture is located in the Tohoku region in northern Japan. It is approximately 500 km away from Tokyo, with a population of some 1.2 million. The cumulative total number of COVID-19 cases as of June 19, 2022, was 9,149,733 and 37,315, including 31,024 and 96 COVID-19-related deaths in Japan and Iwate. The daily new count COVID-19 cases was 13,143 and 65 in Japan and Iwate, respectively (Iwate Prefectural Government, 2022; Ministry of Health Labour and Welfare, 2021). The total number of people who have received their first dose of the vaccination was 1,058,396 and those who have received their second dose of the vaccination was 1,041,219 as of June 19, 2022, in Iwate (Prime Minister's Office of Japan, 2022).

2.2. Data

The Iwate Prefectural Government has conducted online surveys of residents in Iwate Prefecture using a popular social network platform

called LINE (LINE Corporation, Tokyo, Japan) since the beginning of the pandemic. The daily surveys capture information, including the number of newly confirmed cases and the details of situations where people were infected. A series of cross-sectional surveys were started in December 2020 and conducted every two months to determine people's behavioral risks as well as health consciousness for SARS-CoV-2 during the COVID-19 pandemic.

An online questionnaire was administered to approximately 170,000 people who had been registered at the time of the baseline survey. We used the data collected in the fourth survey wave of registered people (from July 2 to 4, 2021), as well as the fifth survey wave (from October 1 to 3, 2021) which were conducted during a period when the vaccine was recommended and available. Responses were received from 22,776 individuals in the fifth survey (response rate, 13%). After excluding subjects who were aged 65 years or more (n=4663), missing data on vaccine hesitancy (n=128) and those who lived outside Iwate (n=71), the analytic sample comprised 17,914 individuals (men, 31.3%) (Fig. 1).

2.3. Outcome

Intention to get vaccinated for COVID-19 was assessed by a single question: "Do you want to receive the COVID-19 vaccine?" The seven possible answers included "I have already received the vaccine," "I want to receive the vaccine, but I cannot," "I want to receive the vaccine," "I possibly want to receive the vaccine," "I am neither willing nor hesitant to receive the vaccine," "I somewhat do not want to receive the vaccine," and "I do not want to receive the vaccine." We grouped the respondents into vaccine hesitant individuals (people who answered the latter three options) versus those vaccine accepters (the first four categories).

2.4. Covariates

The questionnaire in the fifth survey included items about the respondent's age, sex, municipality of residence, occupation, self-rated health, preventive practices, perceived vulnerability, and perceived severity. Regarding age groups, participants selected one group from seven age groups: "under 20 years," "aged 20–29 years," "aged 30–39 years," "aged 40–49 years," "aged 50–59 years," "aged 60–69 years," and "age 70 years old or older." Residential areas were divided into two categories, inland and coastal/mountainous, based on the geographic characteristics of Iwate Prefecture. We defined occupational groups considering people's potential exposure to SARS-CoV-2 in different settings. Occupation was asked with the question, "What is your current job?" Participants selected one of the 11 occupations: transportation, customer-facing occupations in the retail/hospitality sector, office workers, managers in customer-facing industries, advertising or media, workers in manufacturing, unemployed including homemakers, healthcare workers, government workers, teachers, students, farmers/agricultural workers, and workers in other jobs. Participants were grouped into the following seven occupational segments: (i) manufacturing, (ii) service industries (transportation, customer-facing occupations in the retail/hospitality sector, office workers, managers in customer-facing industries, advertising, or media), (iii) healthcare workers, (iv) education sector (teachers or students), (v) government workers, and (vi) unemployed, and (vii) all other (e.g., farmers/agricultural workers, or workers in other jobs). The self-rated health responses were dichotomized into poor self-rated health (not very good or poor) versus good self-rated health in the other remaining options (very good, good, and neither good nor poor). Regarding the respondents' preventive practices, we asked about the following 13 items: hand washing and disinfecting with alcohol, cough etiquette, wearing masks, gargling, refraining from going out when they are not feeling well, limiting social gatherings under the three Cs including closed spaces, crowded places, and close-contact settings, avoiding conversations and vocalizations in the "three Cs" situations, avoiding one or two situations among three Cs situations, avoiding touching face, registering contact

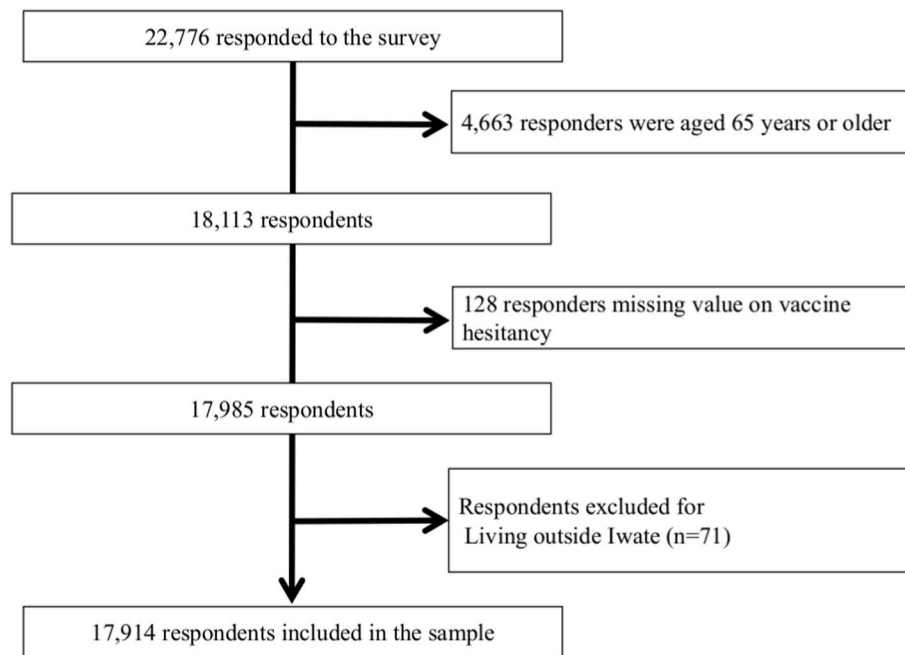


Fig. 1. Flow chart of the selection of respondents. Of 170,000 registered residents, 17,914 residents were selected for this study.

information with apps or memos, regular self-management of health (e. g., checking body temperature), frequent ventilation, and frequent control of humidity. Each item was rated 0 for “no,” 1 for “yes,” and the items were summed to obtain a total score (0–13). Using the overall score, the respondents were classified into four groups: poor level of adoption of control measures (0–6 items), low level of adoption (7–9 items), middle level of adoption (10–11 items), and high level of adoption (12–13 items). *Perceived vulnerability* was asked by the question “How likely do you think you are to contract COVID-19?” Participants selected one of the 5 items: very likely, likely, moderate, unlikely, and very unlikely. We grouped the patients into two groups: likely (very likely and likely) and unlikely (moderate, unlikely, and very unlikely). *Perceived severity* was assessed by asking the question “How serious an illness do you think you will get if you were infected by SARS-CoV-2?” Participants selected one of the following 5 responses: much less serious, less serious, moderate, serious, and more serious. We classified the patients into two groups: less to moderate serious (much less serious, less serious, moderate) and highly serious (serious, and more serious).

The fourth survey wave included items on the number of household members and levels of vaccine knowledge. The number of household members living together was categorized into three groups: living alone, living with two to four people, and living with five or more people. The levels of vaccine knowledge were assessed by asking ‘Please tell us what you know about vaccination information’. The respondents self-reported their knowledge (“yes” or “no”) regarding the following 8 items: (1) the purpose of the vaccine, (2) who was prioritized to receive the vaccine, (3) the approved age for children, (4) persons who should not receive it, (5) whether informed consent was required, (6) whether there was a fee for the vaccine, (7) safety guarantee, and (8) available medications to treat the side effects. Each item was replaced with 0 for “no,” and 1 for “yes.” The responses were summed to obtain a total score (0–8) and were classified as very low level of vaccine knowledge (the score of 0–3), low level of vaccine knowledge (the score of 4 or 5), moderate level of vaccine knowledge (the score of 6 or 7), and high level of vaccine knowledge (score of 8).

2.5. Statistical analyses

To identify segments of the population who had perceived vaccine hesitancy according to occupation, age, and sex, we compared baseline characteristics of participants in the vaccine hesitant group to those expressing vaccine acceptance using the chi-squared test. We stratified respondents by age groups and sex: young men and women (people <40 years), middle-aged men and women (people aged 40–59 years) in the main analyses. We built two logistic regression models to control for the potential pathway variables between occupation and vaccine hesitancy: Model 1, unadjusted model; and Model 2, adding residential area, the number of people living in the same household, self-rated health, adoption of preventive measures, perceived vulnerability, perceived severity, and levels of vaccine knowledge. That is, model 2 includes a number of potential mediating variables that could explain the association between occupation and vaccine hesitancy, including: perceived susceptibility to infection, perceived severity of disease, levels of vaccine knowledge, and practicing preventive measures.

We imputed missing covariate data from the fifth survey wave by multiple imputations using the Markov Chain Monte Carlo method, creating five imputed datasets. For sensitivity analyses, we also conducted analyses using survey weights based on demographic characteristics, including residential areas obtained from the census. The Statistical Package for Social Sciences (SPSS) software program version 25.0 (IBM, Chicago, IL, USA) was used for all analyses. All statistical tests were two-sided, and analysis items with P-values <0.05 were considered statistically significant.

3. Results

Table 1 shows the baseline characteristics of participants in the vaccine hesitant group versus the vaccine acceptance group. Individuals in the hesitant group were significantly more likely to be women aged <40 years. Service workers, workers in the manufacturing industry, unemployed, and the “all other” work categories showed a higher proportion of vaccine hesitancy compared to other occupations. There were significant differences between the two groups in terms of residential areas, self-rated health, engagement in preventive measures, perceived

Table 1
Baseline characteristics of participants in the survey (n=17,914).

		Missing n (%)	Hesitancy (n=986) n (%)	Vaccinated or willingness to get vaccinated (n=16928) n (%)	P value
Age groups	People < 40 years	0 (0.0)	406 (8.0)	4648 (92.0)	<0.001
	People aged 40–59 years		580 (4.5)	12280 (95.5)	
Sex	Men	116 (0.6)	239 (4.6)	4956 (95.4)	0.001
	Women		733 (5.8)	11870 (94.2)	
Occupation	Service industries	0 (0.0)	387 (6.8)	5322 (93.2)	<0.001
	Manufacturing		105 (7.1)	1375 (92.9)	
	Unemployed		123 (8.8)	1273 (91.2)	
	Government workers		78 (4.1)	1809 (95.9)	
	Healthcare workers		64 (1.8)	3524 (98.2)	
	Education sector		64 (3.8)	1604 (96.2)	
Residential areas	All other		165 (7.5)	2021 (92.5)	0.012
	Inland areas	0 (0.0)	808 (5.7)	13300 (94.3)	
	Coastal and mountainous areas		178 (4.7)	3628 (95.3)	
Household members	Living alone	8804 (49.1)	46 (4.1)	1089 (95.9)	0.506
	Living with 2 to 4 persons		304 (4.7)	6128 (95.3)	
	Living with 5 persons or more		77 (5.0)	1466 (95.0)	
Self-rated health	Poor	0 (0.0)	58 (8.3)	639 (91.7)	0.001
	Good		928 (5.4)	16289 (94.6)	
Levels of engagement in preventive measures	Poor	0 (0.0)	319 (7.1)	4167 (92.9)	<0.001
	Low		337 (5.4)	5950 (94.6)	
	Middle		215 (4.9)	4195 (95.1)	
	High		115 (4.2)	2616 (95.8)	
Perceived vulnerability	Unlikely	136 (0.8)	95 (5.7)	13195 (94.3)	0.011
	Likely		175 (4.6)	3613 (95.4)	
Perceived severity	Less to moderate serious	0 (0.0)	174 (12.2)	1255 (87.8)	<0.001
	Highly serious		812 (4.9)	15673 (95.1)	
Levels of knowledge of vaccines	Very low	8607 (48.0)	48 (4.0)	1161 (96.0)	0.527
	Low		60 (4.6)	1242 (95.4)	
	Moderate		164 (5.0)	3104 (95.0)	
	High		164 (4.6)	3364 (95.4)	

Categorical variables are presented as number of cases (%).

P values were calculated using the chi-squared test.

vulnerability, and perceived severity. People with higher level of engagement in preventive measures, perceived vulnerability, and severity were less likely to be hesitant (consistent with the health belief model).

Table 2 shows the risk of vaccine hesitancy in the two models stratified by age group and sex. None of the occupational segments was significantly associated with vaccine hesitancy in men aged <40 years. In women <40 years of age, while the OR of vaccine hesitancy were significantly high in service workers and “all other” in the unadjusted model (Model 1), a significantly high OR in service disappeared after adjustment for other factors, including perceived severity of vaccination (Model 2) (OR [95% confidence interval (CI)] in Model 1: service workers, 1.60 [1.02–2.52]). In people aged 40–59 years, individuals in the service and manufacturing sector, “all other” occupations, as well as the unemployed, had significantly higher ORs of vaccine hesitancy in both sexes. Workers in the manufacturing sector had the second-highest ORs for vaccine hesitancy (men), and the highest ORs for vaccine hesitancy (women) (percentage of vaccine hesitancy [%], OR [95% CI]: men, 6.2%, 2.90 [1.56–5.41]; women, 8.8%, 2.35 [1.38–3.99]). Among both middle-aged men and women, the unemployed was the group most likely to who had perceived vaccine hesitancy, with ORs of 4.45 and 2.39, respectively (Model 1). Women aged 40–59 years in the health care sector had significantly lower ORs for vaccine hesitancy. These associations remained significant even after adjusting for potential mediating variables (Model 2).

Table 3a compared factors that might potentially explain vaccine hesitancy according to occupation. In women <40 years, although service workers show the highest proportion of perceived vulnerability to

infection (28.2% reported they were “highly likely” to contract COVID-19), they simultaneously reported low perceived severity of illness, as well as the lowest levels of self-reported vaccine knowledge (Table 3 (a)). Thus, an insufficient understanding of the potential severity of COVID-19 combined with lower knowledge about vaccines appeared to contribute to the high prevalence of vaccine hesitancy in younger women’s service workers. By contrast, older (40–59 years) service workers had higher perceived susceptibility to exposure/infection as well as higher perceived severity of illness, with approximately 90% of respondents reporting high rates of perceived severity (Table 3 (c) and (d)). Manufacturing workers of both sexes showed low levels of vaccine knowledge, perceived severity of illness, as well as adoption of preventive measures (Table 3c and 3d). While unemployed men have high levels of vaccine knowledge, unemployed men and women also reported the lowest levels of perceived vulnerability to infection, i.e., unemployed people aged 40–59 years do not view themselves at high risk of infection.

To consider selection bias caused by our sampling, we conducted weighted analyses calculated from the spatial distribution of the population in Iwate prefecture (Supplementary Table 1). Survey weights were down-weighting the respondents from large urban areas who were over-represented in our survey. The results were similar to the un-weighted analyses.

We asked vaccine-hesitant individuals about their reasons for vaccine hesitancy (Table 4). Concerns about side effects and safety were frequently cited by workers in all occupations, irrespective of age and sex. Women aged <40 years showed a high percentage of vaccine hesitancy due to concerns about pregnancy or breastfeeding. In older

Table 2a
Results of analysis for risks of vaccine hesitancy in the people <40 years.

		Men <40 years				Women <40 years			
		Model 1		Model 2		Model 1		Model 2	
		OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Occupation	Service industries (ref: government workers)	1.53 (0.79–2.97)	0.205	1.32 (0.67–2.61)	0.429	1.60 (1.02–2.52)	0.04	1.46 (0.93–2.31)	0.102
	Manufacturing	1.10 (0.47–2.58)	0.821	0.84 (0.35–2.03)	0.7	1.16 (0.63–2.14)	0.644	1.03 (0.55–1.92)	0.926
	Unemployed	0.73 (0.09–5.83)	0.766	0.51 (0.06–4.26)	0.535	1.52 (0.91–2.56)	0.113	1.47 (0.87–2.49)	0.148
	Healthcare workers	0.57 (0.20–1.63)	0.296	0.66 (0.23–1.91)	0.441	0.48 (0.28–0.83)	0.008	0.48 (0.28–0.83)	0.008
	Education sector	0.87 (0.38–2.00)	0.749	0.85 (0.37–1.97)	0.71	0.61 (0.35–1.05)	0.075	0.58 (0.33–1.00)	0.051
	All other	2.14 (0.94–4.87)	0.069	1.88 (0.81–4.40)	0.144	2.02 (1.21–3.37)	0.008	1.88 (1.12–3.16)	0.017
	Residential areas	Inland areas (ref: coastal and mountainous areas)			1.16 (0.64–2.11)	0.615			1.14 (0.84–1.55)
The number of households	Living alone (ref: living with 5 persons or more)			1.08 (0.41–2.87)	0.873			1.04 (0.52–2.10)	0.898
	Living with 2 to 4 persons			0.98 (0.50–1.92)	0.949			1.13 (0.66–1.92)	0.641
	Self-rated health	Poor self-rated health			0.86 (0.20–3.81)	0.844			1.11 (0.63–1.98)
Levels of engagement in preventive measures	Poor (ref: high)			2.55 (0.98–6.66)	0.056			1.65 (1.08–2.54)	0.021
	Little			1.57 (0.59–4.23)	0.37			1.26 (0.83–1.91)	0.28
	Middle			0.89 (0.29–2.74)	0.834			1.20 (0.76–1.88)	0.433
Perceived vulnerability	Unlikely (ref: likely)			1.02 (0.58–1.82)	0.941			0.89 (0.66–1.18)	0.407
Perceived severity	Mild to moderate serious (ref: highly serious)			2.79 (1.65–4.72)	<0.001			1.72 (1.22–2.42)	0.002
Levels of knowledge of vaccines	Very low (ref: high)			0.87 (0.37–2.08)	0.75			0.83 (0.46–1.50)	0.526
	Low			0.99 (0.29–3.40)	0.991			0.99 (0.63–1.54)	0.953
	Moderate			1.05 (0.40–2.71)	0.918			1.09 (0.77–1.53)	0.625

Abbreviations: CI, confidence interval; OR, odds ratio.

workers (40–59 years), while perceived vaccine efficacy was high among men's service workers, fear of developing an allergy or chronic diseases was high among women's service workers and the unemployed.

4. Discussion

We investigated occupational disparities in COVID-19 vaccine hesitancy stratified by age and sex groups in a community-based sample in Japan during late 2021 when vaccines were widely available. Among women aged <40 years, workers in the service sector were significantly more likely to have perceived hesitancy (compared to the reference group of government workers). This appeared to be explained by perceived lower severity of illness and low levels of vaccine knowledge in this group. Among people aged 40–59 years, three groups – viz., workers in the service industry, manufacturing industry, and the unemployed – were significantly more likely to have perceived vaccine hesitancy regardless of sex. To the best of our knowledge, this is the first study to examine occupational disparities in vaccine hesitancy stratified by sex and age group.

Previous studies have focused on demographic characteristics associated with COVID-19 vaccine hesitancy in Japan. Vaccine hesitancy was higher among young women in most studies (Kadoya et al., 2021; Khan et al., 2021; Machida et al., 2021; Nomura et al., 2021; Okubo et al., 2021; Sugawara et al., 2021; Yoda & Katsuyama, 2021) and our results are consistent with this finding. Although the age range of participants in previous studies was comparable to ours, the timing of previous studies was during a period (January to February 2021) when

access to the COVID-19 vaccine was restricted to healthcare workers (Kadoya et al., 2021; Khan et al., 2021; Machida et al., 2021; Nomura et al., 2021; Okubo et al., 2021). By contrast, our survey was conducted during a period when the vaccine was recommended and available to all adults (and 80.7% nationally had already received their first shot).

The determinants of COVID-19 vaccine hesitancy vary across countries. Employees in some countries face structural barriers to getting vaccinated. For example, in the United States, Schneider et al. reported that employees did not receive support from their employers for vaccination (only 13% of employees were entitled to paid time off to get the vaccine) (Evelyn et al., 2021). Inadequate support for employees to receive vaccination has been cited as one reason for the low levels of vaccine uptake in the U.S. (Centers for Disease Control and Prevention, 2021). In a UK population-based survey, ethnicity and socioeconomic status with those from South Asian backgrounds and processing a negative attitude public officials and the government were the most unwilling to be vaccinated (Chaudhuri et al., 2022). Socio-demographic, psychological, and predictors of COVID-19 vaccine hesitancy were investigated in South Korea. Younger age, no religious affiliation, political conservatism, and lower family income were significantly associated with vaccine hesitancy (Hwang et al., 2021). In the United States, race and ethnic disparities in vaccine uptake has also contributed to lower overall uptake compared to other countries (Callaghan et al., 2021; Khubchandani et al., 2021; Malik et al., 2020; Reiter et al., 2020). In turn, race/ethnic disparities in the U.S. have multiple causes including inequalities in access to insurance, inequalities in access to paid sick leave, as well as higher levels of medical mistrust among Black

Table 2b
Results of analysis for risks of vaccine hesitancy in the people 40–59 years.

		Men aged 40–59 years				Women aged 40–59 years			
		Model 1		Model 2		Model 1		Model 2	
		OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Occupation	Service industries (ref: government workers)	2.00 (1.13–3.53)	0.017	1.89 (1.06–3.36)	0.031	1.85 (1.17–2.90)	0.008	1.75 (1.11–2.76)	0.016
	Manufacturing	2.90 (1.56–5.41)	0.001	2.49 (1.32–4.72)	0.005	2.35 (1.38–3.99)	0.002	2.17 (1.27–3.70)	0.004
	Unemployed	4.45 (1.66–11.89)	0.003	2.95 (1.06–8.26)	0.039	2.39 (1.47–3.90)	<0.001	2.16 (1.32–3.54)	0.002
	Healthcare workers	0.25 (0.06–1.09)	0.065	0.27 (0.06–1.20)	0.086	0.29 (0.16–0.52)	<0.001	0.30 (0.16–0.54)	<0.001
	Education sector	1.10 (0.44–2.72)	0.841	1.23 (0.49–3.06)	0.662	0.76 (0.38–1.50)	0.424	0.77 (0.39–1.51)	0.44
	All other	2.33 (1.21–4.49)	0.012	2.06 (1.06–4.04)	0.034	1.95 (1.21–3.16)	0.006	1.85 (1.14–2.99)	0.013
	Residential areas	Inland areas (ref: coastal and mountainous areas)			1.04 (0.69–1.57)	0.838			1.33 (1.03–1.74)
The number of households	Living alone (ref: living with 5 persons or more)			0.54 (0.25–1.17)	0.114			0.85 (0.55–1.32)	0.459
	Living with 2 to 4 persons			0.73 (0.45–1.18)	0.192			1.07 (0.76–1.49)	0.708
Self-rated health	Poor self-rated health			2.50 (1.30–4.80)	0.006			1.54 (1.03–2.31)	0.037
Levels of engagement in preventive measures	Poor (ref: high)			1.33 (0.68–2.61)	0.4			1.26 (0.91–1.74)	0.17
	Little			1.20 (0.61–2.35)	0.603			1.08 (0.80–1.47)	0.612
	Middle			1.51 (0.74–3.07)	0.26			1.08 (0.79–1.49)	0.621
Perceived vulnerability	Unlikely (ref: likely)			1.19 (0.74–1.90)	0.469			1.15 (0.86–1.52)	0.344
Perceived severity	Less to moderate serious (ref: highly serious)			3.95 (2.71–5.75)	<0.001			1.77 (1.29–2.43)	<0.001
Levels of knowledge of vaccines	Very low (ref: high)			0.79 (0.36–1.76)	0.554			0.91 (0.54–1.54)	0.711
	Low			1.38 (0.66–2.85)	0.369			0.97 (0.57–1.64)	0.899
	Moderate			1.16 (0.75–1.78)	0.504			1.03 (0.71–1.49)	0.884

Abbreviations: CI, confidence interval; OR, odds ratio.

Table 3a
Comparison of factors associated with vaccine hesitancy according to occupations in the men <40 years (n=1303).

		Missing	Service industries (n=406)	Manufacturing (n=162)	Unemployed (n=24)	Government workers (n=231)	Healthcare workers (n=152)	Education sector (n=222)	All other (n=106)	P-value
Levels of engagement in preventive measures	Low	0 (0.0)	297 (73.1)	121 (74.7)	18 (75.0)	160 (69.3)	120 (64.7)	5405 (128.3)	76 (71.7)	0.004
	High		109 (26.9)	41 (25.3)	6 (25.0)	71 (30.8)	66 (43.4)	77 (34.7)	30 (28.3)	
Perceived vulnerability	Unlikely	20 (1.5)	292 (73.0)	139 (86.9)	19 (86.4)	187 (82.4)	102 (67.5)	165 (76.0)	82 (77.4)	<0.001
Perceived severity	Likely		108 (27.0)	21 (13.1)	3 (13.6)	40 (17.6)	49 (32.5)	52 (24.0)	24 (22.6)	
	Less to moderate serious	0 (0.0)	55 (13.5)	34 (21.0)	7 (29.2)	20 (8.7)	10 (6.6)	25 (11.3)	17 (16.0)	<0.001
Levels of vaccine knowledge	Highly serious		351 (86.5)	128 (79.0)	17 (70.8)	211 (91.3)	142 (93.4)	197 (88.7)	89 (84.0)	
	Low	767 (58.9)	36 (24.0)	23 (33.3)	2 (18.2)	28 (27.7)	26 (35.2)	35 (38.0)	8 (20.5)	0.153
	High		114 (76.0)	46 (66.6)	9 (81.8)	73 (72.2)	48 (64.9)	57 (61.9)	31 (79.5)	

The variables of levels of engagement in preventive measures and levels of vaccine knowledge were dichotomized (low vs. high).

Categorical variables are presented as number of cases (%).

P values were calculated using the chi-squared test.

Americans, reflecting the history of structural racism and institutional discrimination (Callaghan et al., 2021; Khubchandani et al., 2021; Oliver, 2021).

On top of these factors, political polarization has played a major role in vaccine hesitancy in the U.S. and to a lesser extent, the European region (Reiter et al., 2020). In the U.S., Khubchandani et al. revealed

Table 3b

Comparison of factors associated with vaccine hesitancy according to occupations in the women <40 years (n=3707).

		Missing	Service industries (n=1015)	Manufacturing (n=227)	Unemployed (n=372)	Government workers (n=324)	Healthcare workers (n=848)	Education sector (n=602)	All other (n=319)	P-value
Levels of engagement in preventive measures	Low	0 (0.0)	679 (66.9)	183 (80.6)	213 (57.2)	213 (65.8)	460 (54.3)	406 (67.4)	198 (62.1)	<0.001
	High		336 (33.1)	44 (19.4)	159 (42.8)	111 (34.3)	388 (45.7)	196 (32.6)	121 (37.9)	
Perceived vulnerability	Unlikely	24 (0.6)	722 (71.8)	195 (85.9)	330 (89.2)	263 (81.7)	616 (72.8)	456 (76.5)	259 (81.7)	<0.001
	Likely		283 (28.2)	32 (14.1)	40 (10.8)	59 (18.3)	230 (27.2)	140 (23.5)	58 (18.3)	
Perceived severity	Less to moderate serious	0 (0.0)	116 (11.4)	29 (12.8)	44 (11.8)	24 (7.4)	40 (4.7)	36 (6.0)	36 (11.3)	<0.001
	Highly serious		899 (88.6)	198 (87.2)	328 (88.2)	300 (92.6)	808 (95.3)	566 (94.0)	283 (88.7)	
Levels of vaccine knowledge	Low	2021 (54.5)	132 (29.7)	22 (25.3)	40 (21.4)	42 (28.4)	128 (28.6)	63 (25.6)	28 (22.1)	0.281
	High		312 (70.3)	65 (74.7)	147 (78.6)	106 (71.6)	318 (71.3)	184 (74.5)	99 (78.0)	

The variables of levels of engagement in preventive measures and levels of vaccine knowledge were dichotomized (low vs. high).

Categorical variables are presented as number of cases (%).

P values were calculated using the chi-squared test.

Table 3c

Comparison of factors associated with vaccine hesitancy according to occupations in the men 40–59 years (n=3892).

		Missing	Service industries (n=1511)	Manufacturing (n=530)	Unemployed (n=65)	Government workers (n=671)	Healthcare workers (n=354)	Education sector (n=286)	All other (n=475)	P-value
Levels of engagement in preventive measures	Low	0 (0.0)	1079 (71.4)	414 (78.1)	45 (69.2)	404 (60.2)	180 (50.9)	167 (58.4)	390 (82.1)	<0.001
	High		432 (28.6)	116 (21.9)	20 (30.8)	267 (39.7)	174 (49.2)	119 (41.6)	85 (17.9)	
Perceived vulnerability	Unlikely	30 (0.8)	1144 (76.2)	422 (80.7)	56 (88.9)	548 (81.9)	250 (70.8)	217 (76.1)	388 (82.9)	<0.001
	Likely		357 (23.8)	101 (19.3)	7 (11.1)	121 (18.1)	103 (29.2)	68 (23.9)	80 (17.1)	
Perceived severity	Less to moderate serious	0 (0.0)	163 (10.8)	75 (14.2)	15 (23.1)	51 (7.6)	22 (6.2)	12 (4.2)	62 (13.1)	<0.001
	Highly serious		1348 (89.2)	455 (85.8)	50 (76.9)	620 (92.4)	332 (93.8)	274 (95.8)	413 (86.9)	
Levels of vaccine knowledge	Low	1911 (49.1)	199 (26.4)	85 (33.1)	9 (21.4)	87 (23.1)	61 (31.0)	41 (29.4)	57 (26.2)	0.108
	High		554 (73.6)	172 (67.0)	33 (78.6)	289 (76.8)	136 (69.1)	98 (70.5)	160 (73.7)	

The variables of levels of engagement in preventive measures and levels of vaccine knowledge were dichotomized (low vs. high).

Categorical variables are presented as number of cases (%).

P values were calculated using the chi-squared test.

that Republicans and Independents were more likely to be vaccine hesitant compared to Democrats (Khubchandani et al., 2021). Callaghan et al. also showed that the ORs of COVID-19 vaccine refusal are significantly higher for conservatives and people who intended to vote for the incumbent president in 2020, as well as people showing high levels of religiosity (Callaghan et al., 2021). The important point to note here is that Americans who are vaccine hesitant are not a monolithic entity; instead, they are highly segmented groups, each with their unique reasons for refusing the vaccine. Such complexity poses a significant barrier to design interventions (such as mass media campaigns) to boost vaccine acceptance. In contrast, the situation of vaccine hesitancy in Japan is quite different from the United States. There is far less political polarization contributing to the politicization of public health measures to control the pandemic. Japanese society is also more racially and ethnically homogeneous. Fewer than two percent of Japanese identify themselves as religious. All workers are guaranteed paid sick leave. Furthermore, the Ministry of Health, Labour and Wealth of Japan recommended that a new leave system be established that could be used in

situations such as vaccination and medical treatment in case of adverse reactions after vaccination. In addition, the Japanese government guaranteed that if an individual developed an adverse reaction to the vaccine, they would be eligible to receive monetary support, such as funds for medical treatment and disability pension benefits.

On the other hand, Japan does have a history of vaccine skepticism; for example, following the highly publicized cases of purported adverse effects during the rollout of the human papillomavirus (HPV) vaccine program in the 2010s (Gordon & Reich., 2021). A Lancet study indicated that the Japanese people generally express low confidence in vaccines, with the lowest-ranked confidence for vaccine effectiveness and safety (de Figueiredo et al., 2020). Nonetheless, in spite of an initially slow rollout, Japan has achieved a higher rank in the share of people vaccinated against COVID-19 compared to most Western countries as of February 7, 2022 (e.g., percentage of people partially vaccinated against COVID-19 reached 80.5% in Japan, compared to 75.5% in the United States) (Hannah et al., 2022). To date, the government of Japan has not adopted mandatory vaccination regulations, while other countries have

Table 3d
Comparison of factors associated with vaccine hesitancy according to occupations in the women 40–59 years (n=8896).

		Missing	Service (n=2743)	Manufacturing workers (n=554)	Unemployed including homemakers (n=922)	Government workers (n=652)	Healthcare workers (n=2214)	School (n=543)	Other (n=1268)	P-value
Levels of engagement in preventive measures	Low	0 (0.0)	1597 (58.2)	401 (72.4)	473 (51.3)	333 (51.1)	1006 (45.5)	252 (46.4)	706 (55.7)	<0.001
	High		1146 (41.7)	153 (27.7)	449 (48.7)	319 (48.9)	1208 (54.5)	291 (53.6)	562 (44.3)	
Perceived vulnerability	Unlikely	62 (0.7)	2155 (79.0)	490 (89.4)	834 (91.4)	535 (82.6)	1550 (70.3)	419 (77.3)	1069 (85.4)	<0.001
	Likely		573 (21.0)	58 (10.6)	78 (8.6)	113 (17.4)	654 (29.7)	123 (22.7)	183 (14.6)	
Perceived severity	Less to moderate	0 (0.0)	193 (7.0)	42 (7.6)	102 (11.1)	24 (3.7)	55 (2.5)	13 (2.4)	95 (7.5)	<0.001
	Highly serious		2550 (93.0)	512 (92.4)	820 (88.9)	628 (96.3)	2159 (97.5)	530 (97.6)	1173 (92.5)	
Levels of vaccine knowledge	Low	3846 (43.2)	377 (25.7)	83 (28.3)	153 (27.3)	102 (26.3)	363 (27.8)	89 (25.6)	178 (25.9)	0.856
	High		1090 (74.3)	210 (71.6)	408 (72.8)	287 (73.8)	941 (72.2)	259 (74.4)	510 (74.1)	

The variables of levels of engagement in preventive measures and levels of vaccine knowledge were dichotomized (low vs. high). Categorical variables are presented as number of cases (%). P values were calculated using the chi-squared test.

already started (Burki, 2022). However, our results indicate that a higher uptake rate of the COVID-19 vaccine might be achieved in the Japanese population without a mandatory vaccination program.

Service workers tended to be more hesitant toward vaccination, particularly women aged <40 years. Although service workers are more likely to be exposed to SARS-CoV-2 due to the nature of their work, younger workers are also less likely to become severely ill due to COVID-19 (Rosen et al., 2021). Hence, being more hesitant about vaccination may be partly based on a “rational” calculation of the risks and benefits of vaccination. In the present study, the elevated OR of vaccine hesitancy in service workers (particularly women aged <40 years) disappeared after adjusting for perceived severity of illness in women aged <40 years. Younger women’s workers also expressed more concern about potential side effects, particularly related to impacts on pregnancy or breastfeeding (Kadoya et al., 2021). Although the introduction of COVID-19 vaccines did not result in significant resistance among people in Japan, younger women are still concerned about the long-term effects of vaccination on fertility (Gordon & Reich., 2021). Based on the foregoing, Japanese government should focus efforts on educating younger service workers about the safety of COVID-19 vaccines, as well as emphasizing the importance of protecting others in the community (i.e., a pro-social motivation as opposed to narrow self interest).

Among older (40–59 years) workers, Table 3 (c) and (d) indicate that service workers recognized that they were more likely to be infected, as well as to end up with severe illness. After the Japanese government and local government recognized the high risk of COVID-19 in this group, they pushed to provide on-site vaccination for service workers in both large companies and in small and medium-sized companies. Nonetheless, reports suggested persistently high rates of vaccine hesitancy among service workers. One reason given is that, despite being eligible for paid sick leave, many employees in customer-facing occupations in the retail/hospitality sector are reluctant to get the job *in case they develop side effects* and end up taking time off work. They felt this would inconvenience their employers, and potentially result in poor evaluations, retaliation, or worse (unpublished data collected by Iwate prefecture health department). In addition, many workers appeared to equate the decision to get COVID-19 vaccine with receiving the seasonal flu shot, where the annual flu vaccination is viewed as a matter of personal choice. When deciding to get vaccinated for COVID-19, service workers might view their decision based on a balance of risks and

benefits *to the self*, but neglect to consider risks and benefits to others in society. Thus, we speculate that insufficient support in the workplace and in the decision process might lead to hesitation to receive the vaccine. Strategies to motivate workers to receive the vaccine should therefore include implementing stronger regulation for sick leave entitlement for all workers and addressing health communication about herd immunity.

Manufacturing workers of both sexes were more likely to be vaccine hesitant even after adjustment for potential mediating variables. Previous studies have shown a high rate of vaccine hesitancy among manufacturing workers, but the findings have not been consistent, with results indicating either a high rate of vaccine hesitancy (King et al., 2021) or no association (Nomura et al., 2021). In the US study of adults aged 18–64 years, construction and extraction occupancies had the highest percentage of vaccine hesitancy due to strong beliefs about the government, or the vaccine-producing process (percentage of vaccine hesitancy [95% CI], 45.2% [43.7–46.8]) (King et al., 2021). In a Japanese study, individuals aged ≥20 years and working in construction and manufacturing did not have significantly elevated ORs for vaccine hesitancy, whereas finance and insurance workers had significantly higher ORs (Nomura et al., 2021). Although the study design was compatible with ours (cross-sectional study), the stratified analyses by age and sex groups, and the timing of their survey differed (before vs. after vaccine availability for citizens).

Workers in the manufacturing sector mainly work outdoors or in uncrowded environments; therefore, they might (accurately) regard themselves as having a low risk of contracting COVID-19 (King et al., 2021). However, the ORs for vaccine hesitancy remained significantly high after adjustment for perceived vulnerability to getting infected. Although we could not determine the reasons why this group had perceived vaccine hesitancy, potential explanations include concerns about side effects, access to vaccines, lower health literacy, as well as attitudes to health and prevention in general, combined with low trust of government. Concerns about the side effects of vaccines are the most commonly cited reason for vaccine hesitancy among women in the manufacturing sector (Table 4). Regarding accessibility, many cited that they were too busy to take time off to get the vaccine. Manufacturing workers with lower levels of educational attainment are also more likely to have lower health literacy and lower trust in health care professionals. Silva et al. indicated that higher literacy is significantly associated with

Table 4
Reasons for vaccine hesitancy by occupations among the individuals who answered hesitate vaccines.

Occupational categories	Reasons	Sex and age groups			
		Men <40 years	Women <40 years	Men aged 40–59 years	Women aged 40–59 years
Service industries (n=386)	Side effects	23 (67.6)	83 (69.2)	32 (48.5)	106 (63.9)
	Having an allergy or chronic disease	9 (26.5)	32 (26.7)	14 (21.2)	56 (33.7)
	Vaccine hesitancy during pregnancy or breastfeeding	0 (0.0)	7 (5.8)	0 (0.0)	0 (0.0)
	A higher risk for side effects rather than severe state with contracting COVID-19	10 (29.4)	39 (32.5)	17 (25.8)	43 (25.9)
	Safety	23 (67.6)	84 (70.0)	36 (54.5)	103 (62.0)
	Efficacy	7 (20.6)	19 (15.8)	11 (16.7)	13 (7.8)
	Others	3 (8.8)	8 (6.7)	7 (10.6)	12 (7.2)
Manufacturing (n=105)	Side effects	8 (80.0)	15 (75.0)	20 (60.6)	29 (69.0)
	Having an allergy or chronic disease	2 (20.0)	2 (10.0)	3 (9.1)	6 (14.3)
	Vaccine hesitancy during pregnancy or breastfeeding	0 (0.0)	3 (15.0)	0 (0.0)	1 (2.4)
	A higher risk for side effects rather than severe state with contracting COVID-19	2 (20.0)	10 (50.0)	9 (27.3)	14 (33.3)
	Safety	6 (60.0)	13 (65.0)	15 (45.5)	25 (59.5)
	Efficacy	2 (20.0)	4 (20.0)	3 (9.1)	6 (14.3)
	Others	0 (0.0)	0 (0.0)	2 (6.1)	2 (4.8)
Unemployed (n=121)	Side effects	1 (100.0)	29 (69.0)	4 (66.7)	46 (64.8)
	Having an allergy or chronic disease	0 (0.0)	8 (19.0)	2 (33.3)	27 (38.0)
	Vaccine hesitancy during pregnancy or breastfeeding	0 (0.0)	10 (23.8)	0 (0.0)	1 (1.4)
	A higher risk for side effects rather than severe state with contracting COVID-19	1 (100.0)	13 (31.0)	1 (16.7)	10 (14.1)
	Safety	0 (0.0)	27 (64.3)	3 (50.0)	44 (62.0)
	Efficacy	0 (0.0)	3 (7.1)	7 (9.9)	

Table 4 (continued)

Occupational categories	Reasons	Sex and age groups			
		Men <40 years	Women <40 years	Men aged 40–59 years	Women aged 40–59 years
All others (n=133)	Others	0 (0.0)	3 (7.1)	1 (16.7)	3 (4.2)
	Side effects	5 (41.7)	32 (69.6)	11 (45.8)	49 (60.5)
	Having an allergy or chronic disease	1 (8.3)	11 (23.9)	3 (12.5)	26 (32.1)
	Vaccine hesitancy during pregnancy or breastfeeding	0 (0.0)	5 (10.9)	0 (0.0)	3 (3.7)
	A higher risk for side effects rather than severe state with contracting COVID-19	4 (33.3)	15 (32.6)	4 (16.7)	20 (24.7)
	Safety	10 (83.3)	29 (63.0)	11 (45.8)	52 (64.2)
	Efficacy	3 (25.0)	5 (10.9)	5 (20.8)	8 (9.9)
Others	2 (16.7)	6 (13.0)	0 (0.0)	4 (4.9)	

Variables indicate the number of case (percentage).

greater health consciousness with regard to COVID-19 prevention (Silva & Santos, 2021). A low level of health consciousness is in turn linked to behaviors such as ignoring requests for preventive behaviors, including vaccination. Indeed, some workplace outbreaks have been reported in manufacturing in our study areas. We further compared factors associated with vaccine hesitancy between the sexes in people <40 years and those aged 40–59 years (Supplementary Table 2). Among workers aged 40–59 years, men and those with low to moderate perceived severity had a significantly higher OR of vaccine hesitancy.

Regarding the unemployed, previous studies have examined the association between unemployment and vaccine intention (Hwang et al., 2021; Khubchandani et al., 2021). However, the results have not been consistent, with findings indicating either vaccine acceptance (Khubchandani et al., 2021) or vaccine hesitancy (Hwang et al., 2021). For example, a study in South Korea, which has similar ethnic and cultural characteristics to Japan, showed that people without a job had a significantly higher prevalence of vaccine hesitancy than those with a job in the South Korean national survey (n= 13,021 in October and December 2020) (Hwang et al., 2021). In contrast, individuals who were unemployed had the lowest ORs for vaccine hesitancy in a national survey in the United States (n=1878 in June 2020). In studies with Japanese subjects, while employment status was not significantly associated with vaccine hesitancy by sex and age groups (n=4253 in February 2021) (Khan et al., 2021), unemployed individuals had significantly lower vaccine hesitancy in another study (n=23,142 in Feb 2021) (Okubo et al., 2021). Thus, we could not determine whether unemployment is robustly related to vaccine hesitancy. Further studies are required to elucidate this association.

It is true that unemployed people and homemakers are at lower risk of infection due to less opportunity for contact with other people (co-workers, customers). Nonetheless, there are some additional reasons why unemployed people have a high prevalence of vaccine hesitancy. First, they were not eligible to receive the vaccine. Table 4 shows that side effects and fear of developing an allergy or chronic diseases were

relatively high among unemployed people (the prevalence of reasons for vaccine hesitancy: men, 33.3%; women, 38.0%). Secondly, this group may have experienced difficulties in accessing COVID-19 vaccination sites due to the level of demand exceeding supply. Thirdly, some unemployed women with vaccine hesitancy indicated fear of side effects (14.4% in Table 4); more than the proportion who feared severe illness from COVID-19. The rollout of the COVID-19 vaccine occurred earlier in men than in women in Japan because of the early introduction of vaccination programs through workplaces. That is, women's labor force participation is lower in Japan compared to other industrialized countries. As a result, when the government pushed the vaccine rollout through workplace channels, a gender gap inevitably ensued. In turn, when many women saw their partners suffer from post-vaccination side effects, they may have become more hesitant to vaccinate.

Although the "other" category in our study includes a heterogeneous mix of occupations, part-time workers are likely to be over-represented in this group. In turn, Japanese women are much more likely to be engaged in part-time work compared to men. Working Japanese women frequently juggle housework and childcare with their part-time jobs. Barriers to receive vaccination in this group included lack of time to make an appointment. Second, there were differences in access to vaccines between full-time workers and part-time workers. The Japanese government attempted to accelerate vaccine uptake through workplace vaccination, but many people experienced difficulty in scheduling appointments due to overwhelming demand & poor management by local governments. Part-time workers in some workplaces were not included in the workplace vaccination program. Among part-time workers, some people received the vaccine in clinics or workplace vaccination programs accessed through their family members, while others booked through mass vaccination centers provided by the local government. Given the difficulties of making appointments at mass vaccination sites, some people may have given up. Third, some part-time workers were not eligible to paid leave if they developed an adverse reaction after the vaccine. Given all of the foregoing, expanding access to vaccinations for part-time workers should be a priority, e.g., changing the regulation to license pharmacists to administer vaccines (in Japan only medical professionals are currently licensed).

4.1. Limitations

The strength of our study is that we identified specific occupational segments associated with vaccine hesitancy. However, the present study has several limitations. First, we did not ask questions about educational attainment, job titles, current employment status (full-time or part-time), household income, or health status, including comorbidities. We did not inquire about some key determinants of vaccine acceptance, such as experiences of side effects from the first shot, or personal medical history. Second, our dichotomization of intention to get vaccinated for COVID-19 may not be sufficiently sensitive given that most people answered somewhere in the middle between vaccine acceptance/readiness and rejection/denial. Third, office employees in clinics and hospitals could choose either healthcare workers or customer-facing occupations in the retail/hospitality sector. Office employees in clinics and hospitals were more likely to be exposed to SARS-CoV-2 and tended to choose to receive the vaccine compared with service workers in the retail/hospitality sector. We may have under-estimated the possibility of vaccine hesitancy among customer-facing occupations in the retail/hospitality sector. We believe the direction of our attrition bias is conservative. Fourth, selection bias was inevitable because registered individuals in online health surveys were more likely to be digitally experienced users; in particular, older adults, lower educated people, and lower occupational classes such as farmers/agricultural workers tended to participate less in the present survey. Comparing the characteristics of the participants in the fifth survey (October 2021) with the characteristics of the whole population in Iwate in 2021, young and older individuals and men were higher in the census data than in the

present survey. (Supplementary Table 3). A higher proportion of women aged 40–59 years living in inland areas was enrolled in the present study. Finally, the response rate in the survey was low, but fairly typical of community-based surveys. In order to evaluate the potential for selection bias, we compared the characteristics of the local Iwate population (based on Census data) and our sample of 22,776 respondents (Supplementary Table 4). The percentages of both younger and older people as well as the percentage of men were higher in the Census data than in our survey respondents. There was a higher proportion of middle-aged women living in inland areas in our survey. People who respond to surveys tended to have a higher level of consciousness about avoiding exposure/infection compared to non-respondents. Hence, we may have under-estimated the true proportion in vaccine hesitancy in our sample.

5. Conclusion

We determined occupational disparities in vaccine hesitancy stratified by sex and age and groups. While complex and heterogeneous reasons for COVID-19 vaccine hesitancy have been cited in Western countries (e.g., mistrust of government, medical mistrust, and conspiracy beliefs), the situation in Japan may be more amenable to educational interventions targeting specific occupations. In an effort to minimize the potential risks of infection, the government should design health communications tailored to each occupation.

Declaration of interests

All authors have no conflicts of interest to disclose.

Ethics considerations

The surveys were conducted in accordance with applicable Japanese law and Iwate Prefectural Government policy. Since this study was a secondary analysis using anonymized data from Iwate Prefecture, the study was exempt from IRB review.

CRediT authorship contribution statement

Shuko Takahashi: Funding acquisition, Conceptualization, Formal analysis, Writing – original draft. **Naomi Takahashi:** Investigation, Writing – review & editing. **Satoshi Sasaki:** Investigation, Project administration, Writing – review & editing. **Masaru Nohara:** Project administration, Resources, Supervision, Writing – review & editing. **Ichiro Kawachi:** Methodology, Supervision, Validation, Writing – review & editing.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2022.101226>.

References

- Burki, T. (2022). COVID-19 vaccine mandates in Europe. *The Lancet Infectious Diseases*, 22, 27–28.
- Callaghan, T., Moghtaderi, A., Lueck, J. A., Hotez, P., Strych, U., Dor, A., et al. (2021). Correlates and disparities of intention to vaccinate against COVID-19. *Social Science & Medicine*, 272, 113638–113638.
- Centers for Disease Control and Prevention. (2021). *Workplace vaccination program*. USA: Centers for Disease Control and Prevention. <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/essentialworker/workplace-vaccination-program.html>. (Accessed 4 February 2022).
- Chaudhuri, K., Chakrabarti, A., Chandan, J. S., & Bandyopadhyay, S. (2022). COVID-19 vaccine hesitancy in the UK: A longitudinal household cross-sectional study. *BMC Public Health*, 22, 104.
- Evelyn, B., Annette, G., Kristen, H., & Daniel, S. (2021). *Half of service sector workers are not yet vaccinated for COVID-19: What gets in the way? USA: Malcolm wiener center for social policy*. Harvard Kennedy School. <https://shift.hks.harvard.edu/half-of-service-sector-workers-are-not-yet-vaccinated-for-covid-19-what-gets-in-the-way/>. (Accessed 4 February 2022).
- de Figueiredo, A., Simas, C., Karafillakis, E., Paterson, P., & Larson, H. J. (2020). Mapping global trends in vaccine confidence and investigating barriers to vaccine uptake: A large-scale retrospective temporal modelling study. *The Lancet*, 396, 898–908.
- Gordon, A., & Reich, M. R. (2021). The puzzle of vaccine hesitancy in Japan. *Journal of Japanese Studies*, 47, 411–436.
- Hannah, R. E., Lucas, M., Cameron, R.-G., Charlie, A., Esteban, G., Joe, O.-O., Bobbie, H., Diana, M., Max, B., & Roser. (2022). Coronavirus pandemic (COVID-19). Our world in data. Available from: <https://ourworldindata.org/coronavirus>. (Accessed 25 February 2022).
- Hwang, S. E., Kim, W. H., & Heo, J. (2021). Socio-demographic, psychological, and experiential predictors of COVID-19 vaccine hesitancy in South Korea, October–December 2020. *Human Vaccines & Immunotherapeutics*, 1–8.
- Iwate Prefectural Government. (2022). *Information on confirmed cases in iwate. Iwate prefecture*. Iwate Prefectural Government. <https://www.pref.iwate.jp/kurashikan/kyou/iryuu/covid19/index.html>. (Accessed 21 June 2022).
- Joshi, A., Kaur, M., Kaur, R., Grover, A., Nash, D., & El-Mohandes, A. (2021). Predictors of COVID-19 vaccine acceptance, intention, and hesitancy: A scoping review. *Frontiers in Public Health*, 9, Article 698111.
- Kadoya, Y., Watanapongvanich, S., Yuktadatta, P., Putthinun, P., Lartey, S. T., & Khan, M. S. R. (2021). Willing or hesitant? A socioeconomic study on the potential acceptance of COVID-19 vaccine in Japan. *International Journal of Environmental Research and Public Health*, 18(9).
- Khan, M. S. R., Watanapongvanich, S., & Kadoya, Y. (2021). COVID-19 vaccine hesitancy among the younger generation in Japan. *International Journal of Environmental Research and Public Health*, 18(21).
- Khubchandani, J., Sharma, S., Price, J. H., Wiblishauser, M. J., Sharma, M., & Webb, F. J. (2021). COVID-19 vaccination hesitancy in the United States: A rapid national assessment. *Journal of Community Health*, 46, 270–277.
- King, W. C., Rubinstein, M., Reinhart, A., & Mejia, R. (2021). COVID-19 vaccine hesitancy January–May 2021 among 18–64 year old US adults by employment and occupation. *Prev Med Rep*, 24, Article 101569.
- Machida, M., Nakamura, I., Kojima, T., Saito, R., Nakaya, T., Hanibuchi, T., et al. (2021). Acceptance of a COVID-19 vaccine in Japan during the COVID-19 pandemic. *Vaccines*, 9(3).
- Malik, A. A., McFadden, S. M., Elharake, J., & Omer, S. B. (2020). Determinants of COVID-19 vaccine acceptance in the US. *EclinicalMedicine*, 26, Article 100495.
- Milošević Đorđević, J., Mari, S., Vdovič, M., & Milošević, A. (2021). Links between conspiracy beliefs, vaccine knowledge, and trust: Anti-vaccine behavior of Serbian adults. *Social Science & Medicine*, 277, Article 113930.
- Ministry of Health, Labour and Welfare. (2021). *Situation update for COVID-19 and the MHLW's response (Nov. 11, 2021)*. Tokyo: Ministry of Health, Labour and Welfare. <https://www.mhlw.go.jp/stf/covid-19/kokunainohasseijoukyou.html>. (Accessed 21 June 2022).
- Neumann-Böhme, S., Varghese, N. E., Sabat, I., Barros, P. P., Brouwer, W., van Exel, J., et al. (2020). Once we have it, will we use it? A European survey on willingness to be vaccinated against COVID-19. *The European Journal of Health Economics*, 21, 977–982.
- Nomura, S., Eguchi, A., Yoneoka, D., Kawashima, T., Tanoue, Y., Murakami, M., et al. (2021). Reasons for being unsure or unwilling regarding intention to take COVID-19 vaccine among Japanese people: A large cross-sectional national survey. *Lancet Reg Health West Pac*, 14, Article 100223.
- Okubo, R., Yoshioka, T., Ohfujii, S., Matsuo, T., & Tabuchi, T. (2021). COVID-19 Vaccine hesitancy and its associated factors in Japan. *Vaccines*, 9(6).
- Oliver, L. (2021). *Black community tackles vaccine hesitancy in Alabama but Trump supporters resist*. Alabama: The Guardian. <https://www.theguardian.com/us-news/2021/jun/03/alabama-vaccine-hesitancy>. (Accessed 2 March 2022).
- Philip, B. (2021). *Trump and his allies really, really, really want to blame Black Americans and Democrats for vaccine hesitancy*. United States: The Washington post. <https://www.washingtonpost.com/politics/2021/09/13/trump-his-allies-really-really-really-want-blame-black-americans-democrats-vaccine-hesitancy/>. (Accessed 2 March 2022).
- Prime Minister's Office of Japan. (2022). COVID-19 vaccines. Prime Minister's Office of Japan. <https://www.kantei.go.jp/jp/headline/kansensho/vaccine.html>. (Accessed 21 June 2022).
- Reiter, P. L., Pennell, M. L., & Katz, M. L. (2020). Acceptability of a COVID-19 vaccine among adults in the United States: How many people would get vaccinated? *Vaccine*, 38(42), 6500–6507.
- Robinson, E., Jones, A., Lesser, I., & Daly, M. (2021). International estimates of intended uptake and refusal of COVID-19 vaccines: A rapid systematic review and meta-analysis of large nationally representative samples. *Vaccine*, 39(15), 2024–2034.
- Rosen, B., Waitzberg, R., Israeli, A., Hartal, M., & Davidovitch, N. (2021). Addressing vaccine hesitancy and access barriers to achieve persistent progress in Israel's COVID-19 vaccination program. *Israel Journal of Health Policy Research*, 10(1), 43.
- Saito, T., Yamaguchi, T., Kuroda, S., Kitai, T., Yonetsu, T., Kohsaka, S., et al. (2022). Impact of body mass index on the outcome of Japanese patients with cardiovascular diseases and/or risk factors hospitalized with COVID-19 infection. *Journal of Cardiology*, 79(4), 476–481.
- Silva, M. J., & Santos, P. (2021). The impact of health literacy on knowledge and attitudes towards preventive strategies against COVID-19: A cross-sectional study. *International Journal of Environmental Research and Public Health*, 18(10), 5421.
- Sugawara, N., Yasui-Furukori, N., Fukushima, A., & Shimoda, K. (2021). Attitudes of medical students toward COVID-19 vaccination: Who is willing to receive a third dose of the vaccine? *Vaccines*, 9(11).
- Wake, A. D. (2021). The willingness to receive COVID-19 vaccine and its associated factors: "Vaccination refusal could prolong the war of this pandemic" - a systematic review. *Risk Management and Healthcare Policy*, 14, 2609–2623.
- Yoda, T., & Katsuyama, H. (2021). Willingness to receive COVID-19 vaccination in Japan. *Vaccines*, 9(1).