



## Letter to the Editor

## Altered hepatitis C testing and treatment beyond the COVID-19 pandemic



Gamkrelidze et al. reported 25% and 59% drop in hepatitis C virus (HCV) testing and treatment in 2020 compared with 2019 in Georgia.<sup>1</sup> Another recent study reported that HCV testing and treatment dropped by more than 30% before April 2020 and at the beginning of the COVID-19 pandemic in the United States. By the end of 2020, HCV testing recovered, but its treatment rate remained low.<sup>2</sup> During the COVID-19 pandemic, some budget and health policy priorities changed, negative economic issues were seen, and lockdowns, stay-home orders, and physical distancing were opposed. All these factors can lead to closing of some outpatient clinics and harm reduction facilities, decreasing the activities of awareness-raising campaigns such as NOHEP, and consequently decreasing the HCV testing, treatment uptake, and treatment adherence.<sup>3–5</sup> This pandemic has also affected the risk behaviors in people who inject drugs, causing an increased risk of HCV incidence and reinfection, and maybe an altered testing and treatment initiation.<sup>5</sup> However, we believe that other possible mechanisms are altering the HCV testing and treatment beyond the COVID-19 pandemic.

As many patients can be managed within the research settings, there may be an association between the amount of HCV testing and treatment and the number of HCV-related publications. A PubMed search (“Hepatitis C”[Mesh] OR “Hepatitis C”[tiab] OR “HCV”[tiab]) retrieves 5289, 4945, 4576, 4480, and 4236 records related to HCV in 2017, 2018, 2019, 2020, and 2021 years, respectively. HCV-related research had a decreasing trend during recent years,<sup>4</sup> which may propose other reasons than the COVID-19 pandemic for altered HCV testing and treatment.

One underlying factor can be related to the HCV prevalence in different periods. A recent modeling study showed a decrease in HCV-infected cases from 63.6 million in early 2015 to 56.8 million in early 2020.<sup>6</sup> The more HCV viremia decreases, finding and treating HCV-infected cases become more complicated. The speed of testing and treatment drops in a population with a lower HCV prevalence. In addition, by spreading HCV testing and cure, the number of difficult-to-treat patients (due to lack of adherence, refusing treatment, resistance to direct-acting antivirals, etc.) increases, which may lower the speed of treatment.

Altered HCV testing and treatment are avoidable if future studies and governments’ policies consider all related mechanisms. To overcome the effects of this pandemic, we need to extend harm reduction, HCV screening, and treatment programs.

Some opportunities such as mass screening and contact tracing provided by this pandemic can help different programs of HCV elimination.<sup>3</sup> Also, we think that micro-elimination strategies can be a choice to increase the treatment uptake.<sup>7</sup> After that, HCV screening among the general population can be a solution in some countries by using the experience of COVID and consequently improving the treatment uptake. Furthermore, there is a need for an extra effort for treating the known HCV-infected patients, as reports show many diagnosed patients remain untreated.<sup>6</sup> Increasing the number of real-world experience studies to provide resources through the research settings and running more awareness-raising campaigns to remind the benefits of HCV elimination can be other keys.

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## Review Paper

## A meta-analysis of COVID-19 vaccine attitudes and demographic characteristics in the United States

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## ABSTRACT

**Objectives:** Despite the potential for COVID-19 vaccination to prevent severe disease and death, vaccine hesitancy is common in the United States, with more than a quarter of eligible Americans yet to receive the first dose. We draw on existing published studies on COVID-19 vaccine attitudes to estimate the overall prevalence of vaccine hesitancy and assess how it varies across demographic groups.

**Study design:** A systematic literature search was conducted to identify and meta-analyze relevant studies, which examined vaccine acceptance and hesitancy in the context of the COVID-19 vaccine.

**Methods:** We meta-analyzed the prevalence rate of vaccine acceptance across all participants as well as for specific demographic subgroups. To assess time effects, we coded each study for the month during which data were collected and subjected the meta-analytic data to a regression analysis. To assess the magnitude of differences between demographic subgroups, we conducted a separate meta-analysis of odds ratios.

**Results:** Across the 46 samples, an average of 61% of participants indicated they were willing to receive the COVID-19 vaccine. The biggest demographic differences were found for race and political affiliation, with Black respondents and Republicans reporting significantly higher vaccine hesitancy than White respondents and Democrats.

**Conclusions:** These results inform current vaccination efforts by identifying the groups that are least likely to get vaccinated and supporting the need for tailored vaccine strategies to alleviate the concerns specific to those populations. Comparing intentions to vaccinate with actual vaccination rates, vaccine hesitancy appears to have declined considerably among women and Black Americans.

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## Introduction

Despite widespread availability, more than a quarter of eligible Americans have yet to receive the first dose of a COVID-19 vaccine.<sup>1</sup> Given the potential for vaccines to reduce disease severity and transmission, it is critical to understand how to improve vaccine uptake. Vaccine hesitancy, however, is not shared equally among different demographic groups in the United States, and Americans may remain unvaccinated for different reasons, requiring different intervention strategies. The aim of this article was to meta-analytically examine the prevalence of vaccine acceptance both generally and within specific subgroups to determine what proportion of people remain

vaccine hesitant and how that varies as a function of demographic group membership.

Vaccine hesitancy, defined by the World Health Organization as “a delay in acceptance or refusal of vaccines despite availability of vaccination services,” exists across social groups in the United States.<sup>2</sup> In the context of COVID-19, early studies have uncovered specific groups at risk of vaccine hesitancy, although no studies have systematically compared COVID-19 vaccine hesitancy across social or demographic groups. This preliminary evidence demonstrates that vaccine hesitancy intersects with vulnerability to COVID-19 and has important implications for reducing the burden of COVID-19 disease in the United States. For example, older adults are the least likely to report vaccine hesitancy and have received vaccinations at rates higher than any other age group. Conversely, long-term care residents and staff are among the most susceptible to infectious diseases such as COVID-19.<sup>4</sup> Yet, states reporting data on long-term care staff have

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indicated that between 30% and 50% of staff accepted the COVID-19 vaccine when it was first offered.<sup>5</sup>

Racial/ethnic disparities in vaccine uptake are also apparent, with lower vaccination rates observed among Black and Hispanic Americans, despite racial/ethnic minorities being at elevated risk for COVID-19-related mortality. This could reflect vaccine hesitancy or barriers in accessing vaccines.<sup>6,7</sup> Similarly, low-income, rural adults and those residing in socially vulnerable communities have been less likely to receive a COVID-19 vaccination, mirroring previous research on H1N1 vaccination.<sup>8</sup>

Research indicates that specific social groups remain unvaccinated and vulnerable to severe COVID-19 disease.<sup>9,10</sup> No studies, however, have compared the prevalence of vaccine hesitancy across different groups and time. The goal of this analysis is to draw on existing published studies on COVID-19 vaccine attitudes to identify how vaccine acceptance rates vary across demographic groups. This meta-analysis will be the first to comprehensively assess the demographic characteristics associated with COVID-19 vaccine acceptance, which has important implications for developing successful, targeted vaccine uptake interventions.

## Methods

### Literature search and inclusion criteria

A systematic literature search was conducted in August 2021 to identify relevant studies, which have examined vaccine acceptance and hesitancy in the context of the COVID-19 vaccine (this review was not registered). Given that such studies could be published in a

broad array of journals (e.g. medical journals and social science journals), we conducted the search using a general search platform (i.e. ArticlesPlus), which simultaneously draws from all databases. That is, this search feature does not require authors to select a predetermined set of databases and instead searches in all databases simultaneously. We paired the following COVID-19-related search terms, *COVID-19* or *Sars-Cov-2* or *coronavirus*, with search terms related to vaccine acceptance (i.e. *vaccine acceptance* or *vaccine compliance* or *vaccine hesitancy* or *vaccine resistance* or *vaccine uptake* or *vaccine intention* or *vaccine willingness*). We also included *jabs* in our search terms to capture studies that used alternative labels for vaccines. Additional studies were located by searching Google Scholar and examining the reference lists of the studies produced through the systematic literature search.

Studies were eligible for inclusion if they measured participants' willingness to receive or decline the COVID-19 vaccine, were conducted in the United States, and reported a sample size and the number of participants who reported they would accept and/or decline the vaccine. Studies were excluded if they assessed vaccine acceptance after experimentally manipulating messaging about the vaccine and/or characteristics about the vaccine, as these estimates do not reflect people's general vaccine acceptance. Both published and unpublished studies were eligible for inclusion. The search procedures described previously yielded a total of 2083 search hits. Screening was completed by the first author, and Fig. 1 displays the number of studies that were excluded in the screening process and the reasons for exclusion. The screening process produced a total of 44 studies with 46 independent samples ( $N = 167,833$ ) that were eligible for inclusion in our analyses.

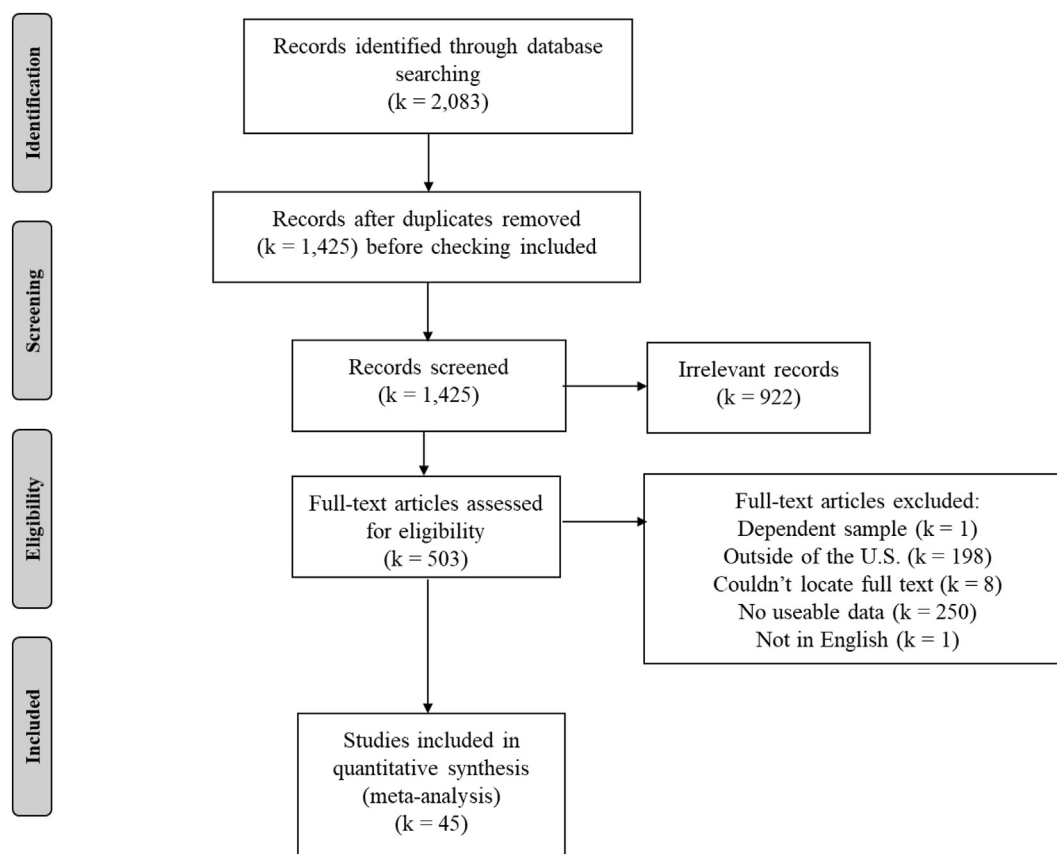


Fig. 1. Flow diagram of the article screening process.

Data coding

Studies were coded for the total number of participants as well as the number of participants who reported they would accept and/or decline the COVID-19 vaccination. Where available, data were also recorded for demographic subgroups within the sample, including sex, race/ethnicity, age, income, education, location, and political affiliation. Sex was categorized as male and female, and race/ethnicity included White, Black, and Hispanic participants. For age, we examined the youngest age group, which typically ranged from 18 to 29 years in primary studies, as well as the oldest age group, which typically included participants aged ≥60 years. Participant education included two categories, which reflected having educational attainment, which fell below earning a bachelor's degree or having earned a bachelor's, professional, or graduate degree. Income was coded as either earning below \$60,000 or above \$60,000, and this cutoff point was used because it roughly corresponds to the median income in the United States. Location was coded as rural or urban/suburban. Political affiliation included identifying with the two major parties in the United States (i.e. Democrat and Republican). The date of data collection was also recorded, and studies were classified as occurring before and after the COVID-19 vaccine was approved for emergency use. Finally, studies were coded for sampling technique, and studies were categorized as probability samples if participants had an equal and known probability of being in the sample. This information was used to assess the possible risk of bias in individual studies, given that non-probability sampling is more likely to produce non-representative samples. The coded information for each included study is available in Table S1 in supplemental materials.

Each study included in the meta-analysis was independently coded by both study authors. Initial agreement across all coded

information was 99%, and any disagreements were discussed until consensus was reached.

Meta-analytic procedures and analyses

The coded data were included in two separate meta-analyses. First, we meta-analyzed the prevalence rate of vaccine acceptance across all participants as well as for specific demographic subgroups. Prevalence rates for each primary study were calculated as the total number of participants who reported they would accept the vaccine divided by the total number of participants. We calculated the average prevalence rate across studies using the Metafor package in R, and analyses were conducted using random effects meta-analytic procedures. We also constructed a forest plot and assessed publication bias for the global prevalence rate estimate using the Metafor package. To assess vaccine attitudes over time, we coded studies for the month of data collection (primary studies ranged from March 2020 to May 2021) and subjected the meta-analytic data to a regression analysis wherein the effect size was the dependent variable and date of data collection was the predictor.<sup>11</sup>

To assess the differences between demographic subgroups, we conducted a separate meta-analysis of odds ratios in which we examined the relative odds of vaccine refusal in each related subgroup (e.g. we conducted an odds ratio to compare men and women). To calculate the odds ratios, we recorded the number of participants in each demographic subgroup who indicated they would refuse and accept the vaccine. We used the Metafor package in R and a random effects model to conduct our meta-analysis of odds ratios, and we present the meta-analytic findings for both the untransformed odds ratios as well as the log-transformed odds ratios (presented in Table 2 only). Odds ratios greater than 1.00

**Table 1**  
Meta-Analytic Results for the Prevalence of Vaccine Acceptance.

Population	k	N	$\bar{p}$	SE	95% CI		Q
					Lower	Upper	
General population	46	167,833	0.61	0.03	0.56	0.66	41,721.46*
Largest N removed	45	94,183	0.61	0.03	0.55	0.66	19,096.41*
Random samples	8	15,796	0.71	0.06	0.60	0.82	2517.46*
Convenience samples	38	152,037	0.59	0.03	0.53	0.65	39,104.77*
Before EUA	28	54,787	0.60	0.04	0.53	0.68	16,808.30*
After EUA	16	112,562	0.62	0.04	0.54	0.70	15,688.47*
Healthcare personnel	9	31,007	0.55	0.05	0.45	0.65	1504.34*
<i>Gender</i>							
Men	19	23,204	0.68	0.04	0.61	0.75	4961.00*
Women	19	37,869	0.58	0.04	0.51	0.66	5489.75*
<i>Race/ethnicity</i>							
White	22	112,641	0.65	0.03	0.59	0.72	18,367.91*
Black	23	8,417	0.44	0.03	0.37	0.50	1279.523*
Hispanic	13	7,824	0.57	0.04	0.49	0.66	1407.88*
<i>Age</i>							
Younger adults	14	5,025	0.56	0.05	0.45	0.66	676.33*
Older adults	14	12,168	0.72	0.04	0.63	0.80	1200.22*
<i>Education</i>							
Less than a college degree	16	14,641	0.57	0.04	0.48	0.66	2454.49*
Bachelor's or graduate degree	16	28,378	0.70	0.04	0.63	0.78	4773.25*
<i>Income</i>							
Income <\$60,000	4	3,091	0.71	0.07	0.57	0.85	252.09*
Income >\$60,000	4	6,387	0.84	0.07	0.71	0.97	206.11*
<i>Location</i>							
Urban	7	21,428	0.54	0.05	0.45	0.63	1149.69*
Rural	7	1,881	0.50	0.05	0.39	0.61	198.98*
<i>Political affiliation</i>							
Democrat	9	6,236	0.70	0.04	0.62	0.78	659.98*
Republican	9	4,075	0.49	0.04	0.40	0.57	268.49*

Note: k = the number of independent samples; N = sample size;  $\bar{p}$  = sample size-weighted mean proportion; SE = standard error of the proportion; 95% CI = 95% confidence interval constructed around the mean proportion; Q = estimate of heterogeneity; Younger adults = people aged 18–29 years; Older adults = people aged ≥60 years.  
\* Indicates significance of less than .05.

**Table 2**  
Meta-analytic results for the relative odds of vaccine refusal.

Construct	k	N	OR	SE	95% CI		Q	OR <sub>log</sub>	SE <sub>log</sub>	95% CI <sub>log</sub>		Q
					Lower	Upper				Lower	Upper	
Women	24	67,912	1.75	0.14	1.48	2.02	1332.52*	0.49	0.08	0.34	0.65	459.45*
Black	25	124,710	3.14	0.30	2.55	3.73	3851.26*	1.00	0.10	0.80	1.21	438.91*
Hispanic	12	99,564	1.58	0.18	1.22	1.94	403.35*	0.37	0.12	0.12	0.61	185.28*
Older adults	14	31,491	0.58	0.07	0.44	0.72	135.28*	-0.64	0.11	-0.85	-0.43	305.43*
Younger adults	14	19,688	1.60	0.23	1.15	2.05	132.60*	0.31	0.11	0.09	0.53	49.46*
Education	15	39,235	2.47	0.29	1.90	3.03	510.49*	0.82	0.10	0.62	1.03	84.75*
Income	5	12,694	2.51	0.69	1.15	3.86	514.99*	0.74	0.28	0.20	1.28	175.95*
Rural	7	19,058	2.02	0.30	1.43	2.62	113.39*	0.63	0.13	0.37	0.89	23.89*
Republican	10	13,317	3.36	0.47	2.43	4.29	1736.63*	1.08	0.17	0.75	1.41	303.70*

Note: k = the number of independent samples; N = sample size; OR = sample size-weighted mean odds ratio; SE = standard error of the odds ratio; 95% CI = 95% confidence interval constructed around the mean odds ratio; Q = estimate of heterogeneity; OR<sub>log</sub> = log-transformed mean sample-weighted odds ratio; SE<sub>log</sub> = standard error of the log-transformed odds ratio; 95% CI<sub>log</sub> = 95% confidence interval constructed around the mean log odds ratio; Women = reference group is males; Black and Hispanic = reference group is White, non-Hispanic respondents; Older adults = compares people aged >60 years to people aged <60 years; Younger adults = compares people aged 18–29 years to people aged >29 years; Education = compares people who earned less than a bachelor's degree to people who earned a bachelor's degree or higher; Income = compares people who earn <\$60,000 to those who earn >\$60,000; Rural = reference group is urban/suburban; Republican = reference group is democrats.

\* Indicates significance of less than .05.

indicate that the group noted in column 1 of Table 2 is more likely to decline the vaccine than their referent group.

We assessed the overall quality of our meta-analytic review using the AMSTAR assessment.<sup>12</sup> Our meta-analysis met all criteria provided in the assessment with one exception, which is that the studies produced by the systematic search were only screened by a single person.

**Results**

*Prevalence rate results*

The results for the general population suggested that across the 46 included samples, an average of 61% (95% confidence interval [CI] 0.56, 0.66) of participants indicated they were willing to receive the COVID-19 vaccine (Table 1). A forest plot of the effect sizes for each study plotted against the sample size is shown in Fig. 2. The studies were also assessed for publication bias, and the funnel plot is shown in Fig. 3. A test of the asymmetry in the funnel plot was not significant (z = -1.25, P = 0.212), indicating no evidence of publication bias. There was one study with a particularly large sample size (N = 73,650), and a similar prevalence rate was found when that study was removed (p̄ = 0.61, 95% CI 0.55, 0.66). Finally, although the prevalence rate was higher in studies that used probability rather than non-probability samples, this difference was not significant.

We separately examined studies that assessed vaccine acceptance among healthcare professionals, given their importance in influencing the decisions of, and their high contact with, patients. The results indicated that roughly half of healthcare personnel were willing to receive the vaccine (p̄ = 0.55, k = 9, 95% CI 0.45, 0.65), which suggests that vaccine acceptance among healthcare professionals may lag behind that seen for other groups. Prevalence rates for the demographic subgroups revealed that women were less likely to accept the COVID-19 vaccine (p̄ = 0.58, k = 19, 95% CI 0.51, 0.66) compared with men (p̄ = 0.68, k = 19, 95% CI 0.61, 0.75). The lowest prevalence of vaccine acceptance was found for Black participants (p̄ = 0.44, k = 23, 95% CI 0.37, 0.50) followed by Hispanic participants (p̄ = 0.57, k = 13, 95% CI 0.49, 0.66), and the highest prevalence for any racial/ethnic group was for White participants (p̄ = 0.65, k = 22, 95% CI 0.59, 0.72).

People who were aged 18–29 years also had a lower prevalence rate of vaccine acceptance (p̄ = 0.56, k = 14, 95% CI 0.45, 0.66) compared with people who were over 60 (p̄ = 0.72, k = 14, 95% CI 0.63, 0.80). Comparisons based on education suggested that a

greater percentage of those with higher educational attainment were willing to receive the vaccine (p̄ = 0.70, k = 16, 95% CI 0.63, 0.78) than those with lower educational attainment (p̄ = 0.57, k = 16, 95% CI 0.48, 0.66). There was similarly a lower prevalence rate of vaccine acceptance among people who earned <\$60,000 (p̄ = 0.71, k = 4, 95% CI 0.57, 0.85) than among people who earned more than \$60,000 (p̄ = 0.84, k = 4, 95% CI 0.71, 0.97). For location, slightly more people were willing to receive the vaccine in urban (p̄ = 0.54, k = 7, 95% CI 0.45, 0.63) compared with rural areas (p̄ = 0.50, k = 7, 95% CI 0.39, 0.61). Finally, half of Republicans reported being willing to accept the COVID-19 vaccine (p̄ = 0.49, k = 9, 95% CI 0.40, 0.57), whereas 70% (k = 9, 95% CI 0.62, 0.78) of democrats were willing to receive the vaccine.

The results indicated that when examining the overall prevalence rate of vaccine acceptance, there was a small but non-significant decline in vaccine acceptance over time (b = -0.01, P = 0.484; Table 3). We additionally assessed vaccine acceptance for each specific subgroup (in cases where there were at least five studies), given that the trajectory of vaccine acceptance rates may have differed as a function of demographic group membership. The results were similar for each subgroup, with the exception of republicans who displayed a significant decrease in vaccine acceptance across time (b = -0.03, P = 0.040) and healthcare professionals who demonstrated decreasing vaccine hesitancy over time (b = 0.16, P < 0.001). We also compared vaccine acceptance prevalence rates before and after the vaccine was approved for emergency use, and the results (Table 1) indicated no significant difference. Finally, Fig. 4 provides a comparison of study prevalence rates with actual vaccination rates.

*Odds ratios results*

The results indicated there were significant differences based on sex, race and ethnicity, age, education, locale, and political affiliation (Table 2). More specifically, women, Black Americans, Hispanic Americans, younger adults, and people living in rural areas were all significantly more likely to decline the COVID-19 vaccine compared with their counterparts. Furthermore, the largest odds ratios were observed for race (i.e. for comparisons of Black and White participants) and political affiliation.

**Discussion**

When estimated across the 46 included samples and nearly 170,000 Americans, less than two-thirds of eligible adults reported



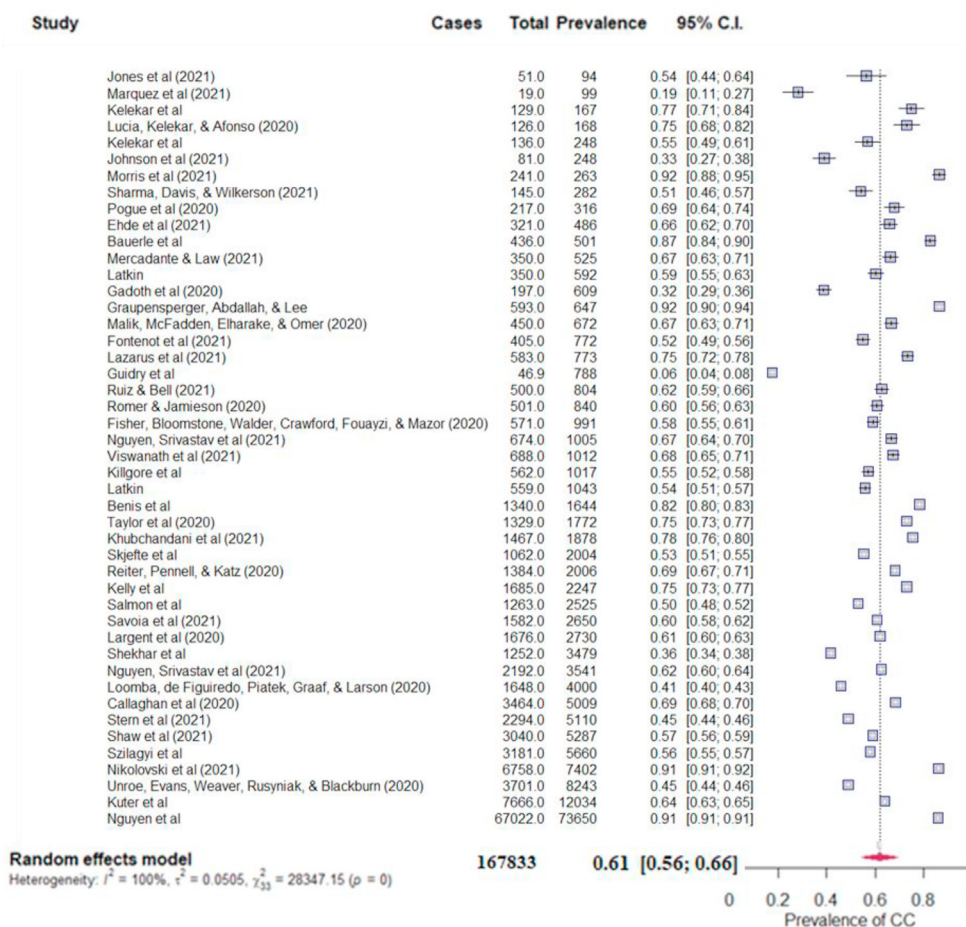


Fig. 2. Forest plot of the proportions extracted from included studies.

they were willing to accept the COVID-19 vaccine. The proportion willing to receive the vaccine, however, varied substantially across demographic subgroups. Indeed, women, Black and Hispanic Americans, younger adults, people with lower educational attainment, people with lower incomes, people living in rural areas, and Republicans were less inclined to receive the COVID-19 vaccine

than their counterparts mirroring national polls from the same period.<sup>13,14</sup> This variation across demographic groups helps explain why a third of eligible Americans remain unvaccinated. Moreover, vaccine hesitancy among healthcare professionals lagged behind most demographic groups.

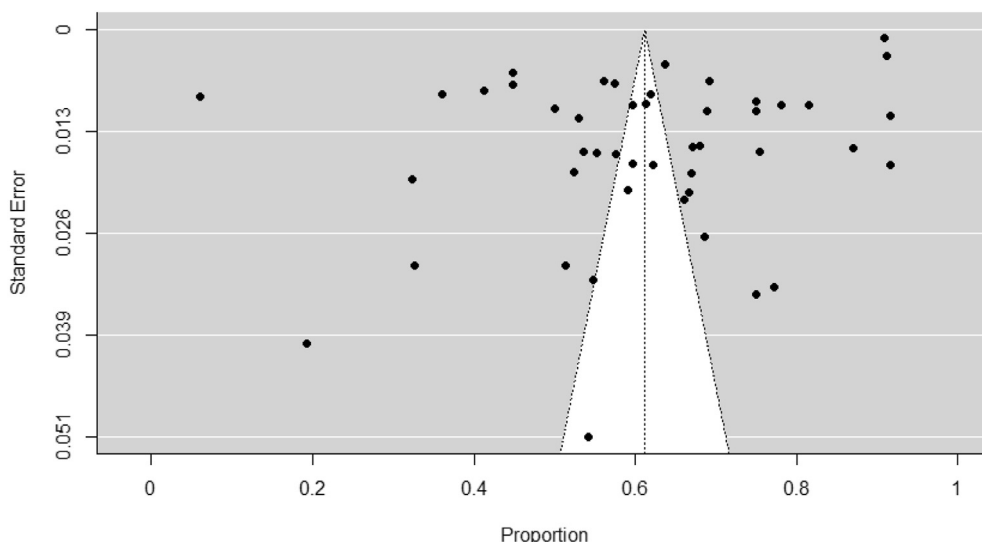


Fig. 3. Funnel plot assessing publication bias in the meta-analysis of proportions.

**Table 3**  
Data collection month predicting vaccine acceptance rates.

Variable	k	B	SE	Q	P	R <sup>2</sup>
General population	44	-0.01	0.01	26.01	0.484	0.02
Healthcare workers	8	0.16	0.03	32.10*	<0.001	0.74
Men	19	-0.01	0.01	12.30	0.293	0.09
Women	19	-0.02	0.01	17.74	0.147	0.12
White	22	-0.01	0.01	11.42	0.461	0.05
Black	23	-0.01	0.01	13.21	0.423	0.05
Hispanic	13	0.01	0.02	6.76	0.769	0.01
Younger adults	14	-0.02	0.01	16.67	0.155	0.12
Older adults	14	-0.02	0.02	8.73	0.150	0.24
Less than a college degree	16	-0.01	0.01	14.01	0.343	0.06
Bachelor's or graduate degree	16	-0.01	0.01	10.89	0.460	0.05
Urban	7	-0.02	0.02	4.86	0.330	0.20
Rural	7	-0.03	0.02	7.21	0.098	0.38
Democrat	9	-0.03	0.02	7.37	0.085	0.40
Republican	9	-0.03	0.01	11.65	0.040	0.36

Note. k = number of effect sizes in the meta-analysis; B = unstandardized regression coefficient for data collection month; Q = estimate of heterogeneity; P = significance value; R<sup>2</sup> = proportion of variance explained.

\* P < .05.

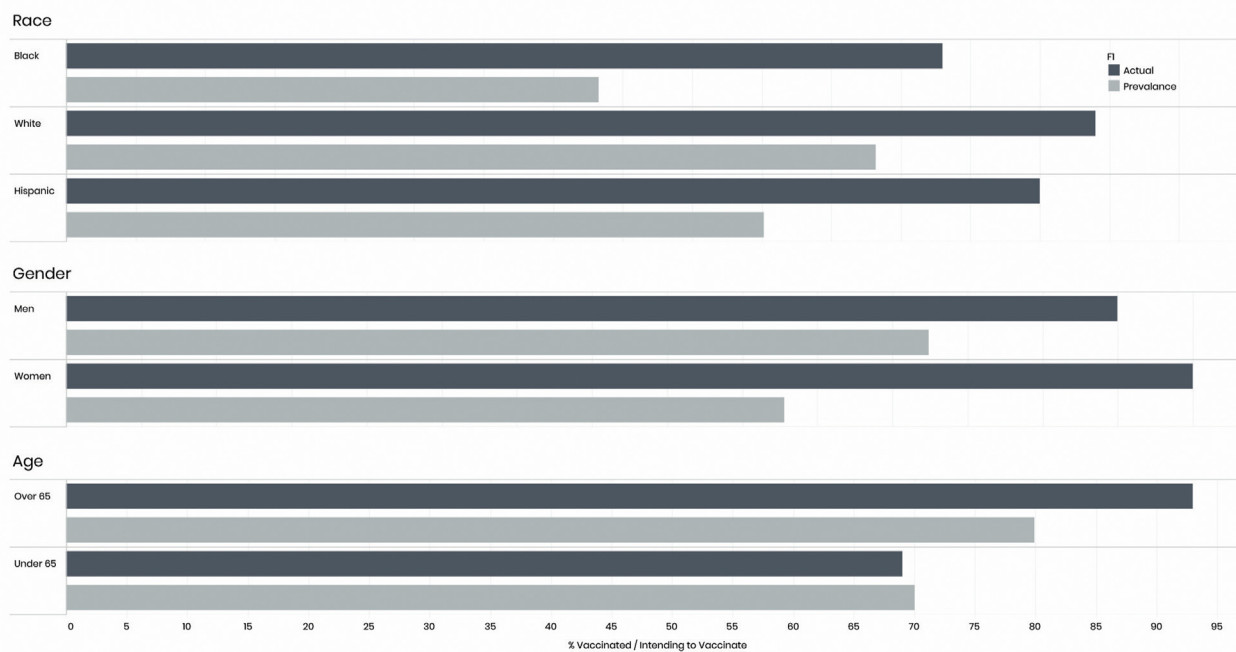
We also found a small but non-significant overall decline in vaccine acceptance across time, with this difference reaching significance among republicans. These findings are consistent with previous survey-based studies, which documented a decline in vaccine acceptance during 2020.<sup>15</sup> As the vaccine development timeline became public, some Americans grew concerned about the speed of the testing and approval process and side-effects documented in clinical trials. The lull in COVID-19 cases in the fall

or general complacency may also have played a role in changing vaccine attitudes.<sup>16</sup> In contrast to the trend observed across all participants, however, healthcare professionals demonstrated an increase in vaccine acceptance over time, whereas republicans demonstrated a significant decrease.

National polls indicate that, since May 2021, vaccine attitudes have continued to improve,<sup>1</sup> but these improvements are not shared equally across demographic groups. Looking at actual vaccination rates (Fig. 4), we find that although women were substantially less likely than men to report a willingness to vaccinate, more women than men actually received COVID-19 vaccination. Despite the widespread, and at times stereotypical, portrayal of Black Americans as vaccine hesitant, we find that the vaccination rate among Black Americans exceeds initial willingness estimates, suggesting that hesitancy may be declining in this group. Conversely, fewer White Americans received vaccinations compared with the percentage who reported being willing to accept the vaccine. These data provide additional context for indexing how vaccine acceptance rates have changed over time and suggest that for women, Black Americans, and people aged >65 years, hesitancy appears to be declining while hesitancy remains stable or is potentially increasing among other groups, including men, Hispanic Americans, and those aged <65 years.

*Public health implications*

This meta-analysis primarily addressed two research questions: (1) how many people intended to get the COVID-19 vaccine and (2) what subgroups are more or less willing to receive the vaccine. These questions can inform interventions to improve COVID-19



**Fig. 4.** Comparison of prevalence and actual vaccination rates for selected demographic groups. Estimates of the reported prevalence rates were derived from the current meta-analytic estimates of the prevalence of vaccine acceptance across demographic groups in the United States. Estimates of the actual vaccination rates were calculated by dividing the number of people in each demographic group who are fully vaccinated by the total number of people in that demographic group who are eligible to receive the vaccine (i.e. the number of people who are aged ≥12 years). Estimates of the total number of people who have received the vaccine were taken from the Centers for Disease Control and Prevention COVID Data tracker. In cases of missing data (i.e. cases where people did not report their demographic information), we multiplied the total number of cases where demographic information was missing by the proportion of that demographic group in the population to approximate the number of cases that were missing from each demographic subgroup. We then added the estimate of missing data to the total of known vaccination cases. Estimates of the total population aged >12 years for each demographic group were taken from the US Census Bureau’s American Community Survey 2019 population estimates. Because the US Bureau reports information for Americans aged ≥65 years, we used 65 as the cutoff to calculate the actual and intended vaccination rates. This differs from our primary analyses in which ≥60 years was used as a cutoff to preserve the maximum number of studies measuring age and vaccine intentions.

vaccine uptake by identifying the scope of the problem (i.e. estimating how many people indicate they are vaccine hesitant or would refuse the vaccine), the populations that are most in need of intervention, and the concerns that a potential vaccine campaign should address. Importantly, a sizable portion of Americans remains hesitant to receive COVID-19 vaccination, which places strain on the US healthcare system and creates disruptions to many social, educational, and economic institutions.<sup>17,18</sup>

Taking the groups with the highest odds of refusing COVID-19 vaccination during the study period as an example, Americans identifying as Republican or Black provides evidence that the factors that undergird hesitancy differ between these and other demographic groups. Studies have demonstrated that key vaccine concerns among Republicans include a lack of trust in government and science<sup>10</sup> as well as exposure to misinformation.<sup>19</sup> Black Americans, by contrast, are more likely to cite a lack of trust in medicine stemming from long-standing mistreatment and exploitation in medical settings.<sup>7,20–23</sup> Interventions to improve vaccine uptake, accordingly, should take a tailored approach to address the concerns specific to demographic subgroups, and our findings help illuminate which groups should be prioritized for interventions to reduce vaccine hesitancy.<sup>14</sup> Others that would likely benefit from targeted interventions include young adults and Americans with lower income or educational attainment. Studies suggest that key concerns in these groups relate to misinformation about infertility and misperceptions that the COVID-19 vaccine is not free and that they may be billed later for the appointment.<sup>24–26</sup>

### Limitations

There are important limitations of the current meta-analysis. First, most of the included studies were cross-sectional, and our analyses would have been strengthened by primary studies that tracked vaccine attitudes across time. Second, there are subgroups of interest that we could not examine in our analyses because of an absence of data. For example, Americans without health insurance and pregnant women may be particularly vulnerable to vaccine hesitancy, and future studies should consider these populations. Finally, there was variability in the measurement of vaccine hesitancy across included studies, and the way in which questions are worded may affect responses. It is possible that such variations therefore altered our estimates of vaccine acceptance.

### Conclusion

Despite widespread availability of COVID-19 vaccines, many Americans remain unvaccinated and vulnerable to severe COVID-19 illness. The findings from the present study provide meta-analytic estimates of Americans' willingness to receive the COVID-19 vaccine as well as estimates of how vaccine acceptance varies across demographic subgroups. These results can inform current vaccination efforts by identifying groups that are less likely to get vaccinated and support the development of tailored vaccine strategies to alleviate specific vaccine concerns.

### Author statements

#### Ethical approval

Because this study did not constitute human subjects research, no approval was required from an institutional review board.

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This study was not financially supported.

### Competing interests

The authors have no conflicts of interest to report.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2022.03.012>.

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## Original Research

# Association between cognitive social capital and all-cause mortality in Great East Japan Earthquake survivors: a prospective cohort study

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## ABSTRACT

**Objectives:** Cognitive social capital (SC), such as attitude, trust, or norms, may help improve resilience among survivors, thus improving their health. However, the association between cognitive SC and the risk of all-cause mortality among survivors after the natural disaster has never been investigated. The purpose of the present study is to investigate the association between cognitive SC and the risk of all-cause mortality among survivors of the Great East Japan Earthquake (GEJE).

**Study design:** Prospective cohort study.

**Methods:** We conducted a health survey on 1654 residents aged  $\geq 18$  years who lived in two areas affected by the GEJE. One year after the GEJE, between June and August 2012, cognitive SC (helping each other, trust, greeting, and solving problems together) was assessed using a self-administrated questionnaire. We divided the subjects into two groups based on response to questionnaire: “high” or “low.” We obtained information on death and emigration from the Residential Registration Record and followed up on the participants from June 2012 to November 2020. The Cox proportional hazards regression analysis was used for estimating the multivariate-adjusted hazard ratios (HRs) and 95% confidence intervals (CIs) for the risk of all-cause mortality according to each cognitive SC indicator.

**Results:** During the 8.5 years of follow-up, 213 subjects died (12.9%). For greeting, compared with subjects who were “high,” subjects who were “low” were significantly associated with the risk of all-cause mortality (HR: 2.92, 95% CI: 1.19–7.17). No statistically significant association was observed for helping each other, trust, and solving problems together.

**Conclusion:** Our findings suggest that perception of greeting may be associated with the risk of all-cause mortality in survivors after natural disasters.

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## Introduction

On March 11, 2011, the Great East Japan Earthquake (GEJE) of magnitude 9.0 and the huge tsunami that followed caused massive damage to coastal areas in the northeast coast of Japan. As a result, approximately 16,000 people are dead, and more than 2500 people are still missing.<sup>1</sup> Ten years have passed since the GEJE, and the number of evacuees has decreased to approximately 40,000 from 470,000 people, of which 1000 people are still in temporary housings.<sup>2</sup> The health impact on survivors who experienced natural

disaster such as flood, bushfire, hurricanes, and earthquake is continuing; it is one of the public health concerns worldwide.

According to Putnam, social capital (SC) refers to “features of social organizations, such as networks, norms and trust that facilitate action and cooperation for mutual benefit” and divided into two components (structural SC and cognitive SC).<sup>3,4</sup> Evidence suggests that both structural SC and cognitive SC assume important roles in the maintenance of health.<sup>5</sup> Many epidemiologic studies reported that structural SC, such as social participation and social networks, were negatively associated with all-cause mortality.<sup>6–9</sup> The Health and Lifestyle Survey in the England has shown that lower social participation is significantly associated with an increased risk of all-cause mortality.<sup>6</sup> In Finland, a population-based prospective study showed that leisure participation was associated with reduced all-cause mortality in men. Murata et al. have reported that higher

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voter turnout rates were associated with lower mortality among men (aged  $\geq 65$  years).<sup>8</sup> A meta-analysis including a total of 28 previous studies found a negative association between social participation and all-cause mortality.<sup>9</sup> Meanwhile, the association between cognitive SC, such as attitude, trust, or norms, and all-cause mortality has remained unclear.<sup>7,10–12</sup> Hyppä et al. reported interpersonal trust was associated with reduced all-cause mortality in women.<sup>7</sup> Similarly, some previous studies also reported a negative association between social trust and all-cause mortality.<sup>10–12</sup> A systematic review of prospective studies reported that most SC indicators did not serve as predictors of all-cause mortality.<sup>13</sup> However, the association between cognitive SC and the risk of mortality has been investigated mainly in the general population but not in the survivors. Thus, no previous study has investigated the prolonged health effect of cognitive SC for disaster survivors.

Cognitive SC might be associated with health outcomes among survivors of disaster such as the GEJE because they were severely affected by loss of family or friends, economic hardship, and relocation. Cognitive SC may help improve resilience among survivors, thus improving their health. However, the association between cognitive SC and the risk of all-cause mortality among survivors after the natural disaster has never been investigated.

Therefore, we analyzed data from a prospective cohort study based on survivor to investigate the association between cognitive SC and the risk of all-cause mortality among survivors of the GEJE and to investigate which factors of cognitive SC are related to all-cause mortality.

## Methods

### Study population and design

We used data from the health survey on survivors that were strongly affected by the GEJE. The details of this study have been reported elsewhere.<sup>14–16</sup> Between June and August 2012, we delivered a questionnaire to all 6407 residents who were aged  $\geq 18$  years in Ogatsu, Oshika, and Ajishima Island, districts of Ishinomaki City, Miyagi Prefecture, northeastern Japan. This was about 16 months after the GEJE when approximately 50% of the residents still lived in prefabricated temporary housing.<sup>13</sup>

The baseline questionnaire included the following information: age, sex, body weight, height, residence status, working status, economic status, dietary condition, physical activity, smoking status, drinking status, history of disease, self-rated health, sleeping status (Athens Insomnia Scale [AIS]),<sup>17</sup> psychological distress (based on the 6-item Kessler Psychological Distress Scale [K6]),<sup>18</sup> Social Networks (Lubben Social Network Scale-6 [LSNS-6]),<sup>19,20</sup> and cognitive SC. The 1796 individuals who returned the questionnaires formed the study cohort. We excluded 105 subjects who did not provide consent to participate in this study, and 37 subjects who had missing questionnaire data regarding cognitive SC. Thus, 1654 subjects were analyzed in the study (Fig. 1).

### Assessment of neighborhood SC

Cognitive SC was assessed by responses to the following four statements: (1) “People in my community help each other.” (helping each other), (2) “People in my community can be trusted.” (trust), (3) “People in my community greet each other.” (greeting), and (4) “If there is a problem in my community, people work together to solve it.” (solving problems together). The subjects were asked to choose one of the following responses: “strongly agree,” “somewhat agree,” “neither agree nor disagree,” “somewhat disagree,” and “strongly disagree.” Then, we divided the subjects into two groups based on response to questionnaire: “high”

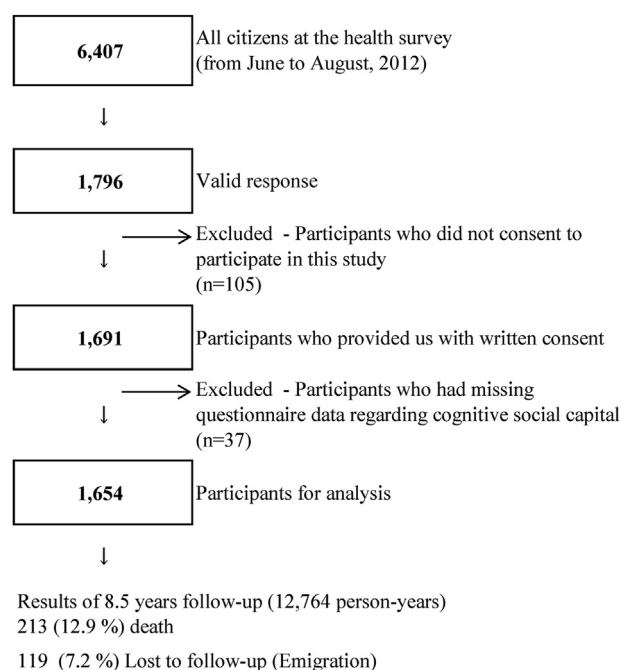


Fig. 1. Flow diagram.

(“strongly agree,” “somewhat agree,” or “neither agree nor disagree”) or “low” (“somewhat disagree” or “strongly disagree”). To investigate which factors of cognitive SC are related to all-cause mortality, we evaluated cognitive SC using four indicators (helping each other, trust, greeting, and problem solving together). The internal consistency of the SC indicators was high, with a Cronbach’s  $\alpha$  of 0.81 for the SC indicators.

### Other measurements

Body mass index (BMI) was calculated as the self-reported current body weight (in kilogram) divided by the square of the self-reported body height (in meter). BMI was categorized into three groups: 18.5, 18.5–24.9,  $\geq 25$  kg/m<sup>2</sup>.

Self-rated health was assessed by asking the question, “What is your state of health?” for which available responses were “very good,” “good,” “poor,” and “bad.” Self-rated health was categorized into two groups: “very good” and “good” or “poor” and “bad.”

Smoking status was categorized into three groups: “non-smoker,” “1–19 cigarettes/day,” and “ $\geq 20$  cigarettes/day.”

Sleeping status was measured using the AIS,<sup>17</sup> which is a self-assessment instrument to report any sleep disorders experienced by the participant, provided that they occurred at least three times per week during the last month. The AIS comprises eight questions rated from 0 to 3, with a total score ranging from 0 to 24. If the total score on the AIS is  $\geq 6$ , the participant is considered to have a sleep disorder [ref].

Psychological distress was measured using the K6 (6-item Kessler Psychological Distress Scale), which is composed of six items rated from 0 to 4, with a total score ranging from 0 to 24.<sup>18</sup> If the total score on the K6 is  $\geq 10$ , the participant is considered to have a psychological distress.

Social networks were measured using the Lubben Social Network Scale 6 (LSNS-6),<sup>19,20</sup> which is composed of six questions rated from 0 to 5, with a total score ranging from 0 to 30. If the total score on the LSNS-6 is  $< 12$ , the participant is considered to be socially isolated.

Mortality and migration ascertainment on follow-up

We followed up the participants from June 1, 2012, to November 30, 2020. The study endpoint in our analysis was the date of death, the date of emigration from Ishinomaki City, or the end of the follow-up period, whichever occurred first. We obtained information on death and emigration from the Residential Registration Record based on an agreement with the Ishinomaki City government related to Epidemiologic Research and Privacy Protection. In this study, 7.2% (n = 119) of the subjects were lost.

Ethical issues

The study protocol was approved by the Institutional Review Board of the Tohoku University Graduate School of Medicine (approval No.: 2011-92, 2017-1-069). Consent to participate in the study was obtained from the participants either face-to-face or via the signed self-administered questionnaires.

Statistical analysis

We prospectively counted person-years of follow-up for each subject from the beginning until the end of follow-up. Next, we used Cox proportional hazards regression analysis to estimate the multivariate-adjusted hazard ratios (HRs) and 95% confidence intervals (CIs) for the risk of all-cause mortality according to the low category of cognitive SC as the reference group. We considered the following variables to be potential confounders: age at baseline (continuous variable), sex (men or women), BMI (18.5, 18.5–24.9, ≥25, or missing), self-rated health (good [very good or good], poor [poor or bad], or missing), smoking status (non-smoker, 1–19 cigarettes/day, ≥20 cigarettes/day, or missing), AIS score (<6, ≥6, or missing), and time spent walking per day (≥1.0 h, <1.0 h, or missing; Model 1).

We also added the LSNS-6 score as a social factor because social isolation may affect the association between cognitive SC and all-cause mortality (Model 2).

We conducted further stratified analysis according to age group (<65 years or ≥65 years) because previous studies have shown that interpersonal trust was predictive of all-cause mortality only in men over 65 years of age.<sup>7,8</sup>

All statistical analyses were performed using SAS statistical software package (version 9.4; SAS Institute Inc, Cary, NC).

**Table 1** Characteristics of participants according to cognitive social capital indicators after the GEJE.

	Cognitive social capital indicators							
	Helping each other		Trust		Greeting		Solving problems together	
	High	Low	High	Low	High	Low	High	Low
No. of participants	1568	86	1554	100	1623	31	1583	71
Men (%)	44.3	50.0	44.6	45.0	44.4	54.8	44.3	52.1
Age, years (SD)	66.9 ± 12.9	63.0 ± 14.7	67.0 ± 12.9	62.5 ± 14.7	66.8 ± 12.9	58.6 ± 17.7	66.9 ± 12.9	62.6 ± 15.3
BMI ≥25 kg/m <sup>2</sup>	22.6	12.8	22.5	15.0	22.3	9.7	22.2	19.7
Economic status, very hard/hard (%)	22.7	32.6	22.5	34.0	23.0	35.5	22.5	39.4
Current smoking (%)	15.8	26.7	15.8	25.0	16.3	19.4	16.1	23.9
Current drinking (%)	32.2	36.1	32.3	34.0	32.4	35.5	32.5	31.0
History of diseases <sup>a</sup> (%)	9.6	8.1	9.7	6.0	9.6	6.5	9.6	7.0
Self-rated health, bad (poor/bad; %)	18.2	30.2	17.9	33.0	18.8	19.4	18.5	26.8
AIS score ≥6 (%)	27.7	46.5	27.4	48.0	28.5	38.7	28.0	43.7
K6 score ≥10 (%)	11.5	30.2	11.1	34.0	12.1	29.0	11.6	32.4
LSNS-6 score <12 (%)	17.9	52.3	17.3	56.0	19.2	45.2	18.1	54.9
Time spent walking <1 hour/day (%)	71.5	81.4	71.6	78.0	71.9	77.4	71.6	81.7

BMI, body mass index; SD, standard deviation.

<sup>a</sup> Stroke, myocardial infarction, and cancer.

Results

Subject characteristics

The study included 738 men and 916 women, with a mean age of 66.7 ± 13.0 years. During the 8.5 years of follow-up between June 1, 2012, and November 30, 2020, 213 subjects died (Fig. 1).

Table 1 shows the baseline characteristics of the study participants according to cognitive social capital indicators. Subjects with lower cognitive SC tended to be younger, have sleep disorders, and suffer from psychological distress. In addition, subjects with lower cognitive SC were likely to have low physical activity and tended to be socially isolated. In contrast, subjects with higher cognitive SC were less likely to have psychological distress and to be socially isolated. However, no significant differences were observed between the interpersonal trust groups in terms of medical history or lifestyle factors such as smoking and drinking.

Cognitive SC indicators and all-cause mortality

Table 2 shows multivariable Cox regression analyses, adjusted for sex, age, BMI, self-rated health, smoking status, AIS score, and time spent walking. We found that only lower greeting was significantly associated with an increased risk of all-cause mortality in model 1. For helping each other, compared with subjects who were “high,” subjects who were “low” tended to be associated with an increased risk of all-cause mortality (HR: 1.20, 95% CI: 0.65–2.22) but not significant. Similarly, for trust, subject who “low” tended to be associated with an increased risk of all-cause mortality (HR: 1.36, 95% CI: 0.75–2.47), but not significant. For greeting, subject who was “low” was significantly associated with an increased risk of all-cause mortality (HR: 2.92, 95% CI: 1.19–7.17) compared with subjects who were “high.” Also, for solving problems, subject who was “low” was not associated with an increased risk of all-cause mortality (HR: 0.95, 95% CI: 0.44–2.05).

To consider the possibility that social networks might affect the association between cognitive SC and the risk of all-cause mortality, we also added the LSNS-6 score (≥12, <12, or missing) to the covariates in the multivariate model. However, the results remained essentially unchanged, even after adjusting for social networks (Model 2). The multivariate HRs (95% CIs) were 1.17 (0.62–2.19) for helping each other, 1.34 (0.73–2.45) for trust, 2.90 (1.18–7.12) for greeting, and 0.93 (0.43–2.00) for solving problems.



**Table 2**  
Hazard ratios (HRs) and 95% confidence intervals (CIs) for all-cause mortality according to cognitive social capital indicators.

	Cognitive social capital	
	High	Low
<b>Helping each other</b>		
No. of participants	1568	86
Person-years of follow-up	12,129	635
No. of deaths	202	11
Model 1 <sup>a</sup>	1.00 (ref)	1.20 (0.65–2.22)
Model 2 <sup>b</sup>	1.00 (ref)	1.17 (0.62–2.19)
<b>Trust</b>		
No. of participants	1554	100
Person-years of follow-up	12,044	720
No. of deaths	201	12
Model 1 <sup>a</sup>	1.00 (ref)	1.36 (0.75–2.47)
Model 2 <sup>b</sup>	1.00 (ref)	1.34 (0.73–2.45)
<b>Greeting</b>		
No. of participants	1623	31
Person-years of follow-up	12,558	206
No. of deaths	208	5
Model 1 <sup>a</sup>	1.00 (ref)	2.92 (1.19–7.17)
Model 2 <sup>b</sup>	1.00 (ref)	2.90 (1.18–7.12)
<b>Solving problems together</b>		
No. of participants	1583	71
Person-years of follow-up	12,219	544
No. of deaths	206	7
Model 1 <sup>a</sup>	1.00 (ref)	0.95 (0.44–2.05)
Model 2 <sup>b</sup>	1.00 (ref)	0.93 (0.43–2.00)

<sup>a</sup> Model 1; adjusted for age at baseline (continuous variable), sex, BMI (18.5, 18.5–24.9, ≥25, or missing), self-rated health (very good/good, poor/bad, or missing), smoking status (non-smoker, 1–19 cigarettes/day, ≥20 cigarettes/day, or missing), AIS score (<6, ≥6, or missing), and time spent walking per day (≥1.0 h, <1.0 h, or missing).

<sup>b</sup> Model 2; adjusted for model 1 plus LSNS-6 score (<12, ≥12, or missing).

We further conducted stratified analysis according to age group (<65 years or ≥65 years) to assess whether the association between cognitive SC and the risk of all-cause mortality differed between subjects who were younger and older survivors. The association between cognitive SC and all-cause mortality risk was consistently observed both <65 years and ≥65 years (Supplementary Table 1).

**Discussion**

In this prospective cohort study conducted among survivors after the GEJE, lower perception of greeting was significantly associated with an increased risk of all-cause mortality. Previous studies showed the association between cognitive SC and all-cause mortality risk in the general population, whereas we demonstrated the association in the GEJE survivors. Our finding suggested that positive greeting might decrease the risk of all-cause mortality in survivors following natural disasters.

According to Putnum, cognitive SC is derived from mental processes and consists of values, attitudes, trust, confidence, and norms.<sup>3,4</sup> The need for cognitive SC may have been higher among survivors of the GEJE because they were forced to endure difficult situations because of the loss of family or friends, economic hardship, and relocation, and they were under more psychological distress compared with the general population<sup>14–16,21</sup> Many studies conducted on survivors after the GEJE have reported that cognitive SC might have a large impact on mental health and resilience.<sup>22,23</sup>

Between June and August 2012, the study subjects were in the process of reconstructing their lives. Therefore, their cognitive SC might have played an important role in their level of resilience.

A trusting and supportive environment may promote health in survivors following natural disasters through healthy behavior or psychological processes and lower the risk of all-cause mortality. In addition, a community with social cohesion may be better able to

prepare for, and recover from, a disaster. Recent studies conducted on survivors after the GEJE have shown that communities plagued by low trust and high crime before the disaster experienced higher rates of mortality.<sup>24</sup> Therefore, the association observed between greeting and all-cause mortality among survivors might support these mechanisms.

The major strengths of our study included its prospective design with 8.5 years of follow-up and adjustment for many potential confounding factors. To our knowledge, this is the first study to have investigated an association between cognitive SC and all-cause mortality among survivors of disaster.

This study also had some limitations. First, the response rate of the health survey was low (28.0%). Therefore, the respondents might have experienced less severe damage than the non-respondents. Second, the sample size might not have been sufficient to allow for accurate analysis. However, the association between cognitive SC and the risk of all-cause mortality did not differ in the three indicators (helping each other, trust, and greeting). Third, cognitive SC indicators were ascertained only once at the time of the health survey using a self-reported questionnaire. Therefore, misclassification might have attenuated the association between cognitive SC and the risk of all-cause mortality. In addition, cognitive SC might have been changed during the follow-up period.

Although the present study is based on a small sample of case, the findings suggest greeting may contribute to improve resilience and decrease the risk of all-cause mortality for survivors of natural disaster. Further research needs to examine more closely the association between cognitive SC and all-cause mortality after the earthquake.

**Conclusion**

In conclusion, this prospective study suggested that perception of greeting may be associated with the risk of all-cause mortality in survivors after natural disasters. Many survivors are likely to have lower cognitive SC due to the loss of family and friends or a change of home and job location. It is necessary to provide community intervention to increase cognitive SC for survivors.

**Author statements**

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*Ethical approval*

The study protocol was approved by the Institutional Review Board of the Tohoku University Graduate School of Medicine. Written informed consent obtained from all participants.

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### Competing interests

None declared.

### Consent for publication

Not applicable.

### Availability of data and material

All data generated or analyzed during this study are not publicly available but are available from the corresponding author on reasonable request.

### Authors' contributions

Y.S. and I.T. designed the research and wrote the initial draft of the article. Y.S. and I.T. contributed to analysis and interpretation of data and assisted in the preparation of the article. Y.Y. and Y.H. have contributed to data collection and interpretation and critically reviewed the article. All authors read and approved the final version of the article.

### Appendix A. Supplementary data

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## Short Communication

## Concerns and coping mechanisms during the first national COVID-19 lockdown: an online prospective study in Portugal

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## ABSTRACT

**Objectives:** The aim of this study was to explore concerns and coping mechanisms during the first national COVID-19 lockdown in Portugal. The general population provided statements via an open comment box as part of an online prospective study.

**Study design:** This was an Internet-based open cohort study.

**Methods:** Individuals aged  $\geq 16$  years were eligible to participate in this study. Inductive content analysis was performed on completed questionnaires submitted between 23 and 29 March 2020 and 27 April and 3 May 2020 (corresponding with the early and late phases of the first national lockdown, respectively).

**Results:** Data suggest the prominence of behavioural and emotional responses to COVID-19; namely, self-compliance with measures promoted by the government; adopting practices of self-care and supporting/protecting others; and enacting hope (both currently and for the future). Concerns were related to the perception of vulnerabilities for oneself, family and others and to challenging situations presenting in society (e.g. physical and mental health, academic/professional careers, income, social inequality, potential discrimination and stigmatisation, inconsistent information and negative approach to the news), coupled with criticism, scepticism or doubts about government policy and performance of the healthcare system. Expressions of fear and worry and non-compliance with mitigation measures by others (e.g. close relatives, employees and general population) emerged as additional concerns.

**Conclusions:** Continuous assessment of behavioural and emotional responses to the COVID-19 pandemic is needed to support effective communication and public health policies that are sensitive to the concerns, motivations and expectations of the population. Awareness of changing public opinions enables governments to continue to effectively mobilise the population to take recommended actions to reduce the transmission of COVID-19.

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## Introduction

The COVID-19 pandemic continues to have disruptive effects on the lives of populations throughout the world.<sup>1</sup> There is a growing body of knowledge about the public's concerns and coping mechanisms in regards to COVID-19 (i.e. behavioural, cognitive and emotional responses to uncertainty and the perception of putting oneself and others at risk).<sup>2</sup> However, most studies investigating public views on COVID-19 during the first lockdown focus on

negative responses, disruptive impacts on psychological status and the fragility of existing mental health services.<sup>3</sup> Other studies suggest a variety of positive and negative coping mechanisms and corresponding effects on mental health.<sup>4</sup>

Knowledge about how the general population responds to severe restrictive measures is useful for future public health actions by informing the design of focused interventions and sensitive communication.<sup>5</sup> Although vaccination coverage is growing in Europe, with Portugal currently having the highest vaccination rate, a high level of uncertainty about the pandemic evolution and future pandemics persists. This complex situation requires more knowledge about the responses of the general population to mitigation measures. This will provide data for future strategies that increase solidarity at interpersonal, group and contractual levels and allow

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governments to continue to effectively mobilise the population to take recommended actions to contain the spread of the virus.<sup>6</sup>

This short report analyses statements from the general population in Portugal regarding different aspects of dealing with COVID-19 during the first national lockdown (18 March to 2 May 2020). Comments were received through an open comment box as part of an online prospective study.

**Methods**

At the beginning of the first lockdown, an Internet-based open cohort study was designed by a multidisciplinary team hosted at the Institute of Public Health of the University of Porto and the Institute for Systems and Computer Engineering, Technology and Science (INESC-TEC), Portugal. Study dissemination and a call for participation were made primarily through a national daily newspaper (PÚBLICO) that partnered with the research team. The research institutions involved also promoted the study through their institutional websites, social networks and mailing lists. In addition, key opinion leaders on public health issues were contacted to support dissemination through their networks.

All individuals aged ≥16 years were eligible to participate in the study. After registering online, participants were sent daily reminders by email to complete a questionnaire on COVID-19-related symptoms, healthcare use and daily activities. The final question posed to participants was the following open-ended question: ‘Feel free to use this space for any comments you may have’. Participants could enter and leave the study whenever they wanted and fill in any number of questionnaires within any period.

Based on the analysis of statements written in the survey’s open comment box for questionnaires submitted between 23 and 29 March 2020 and 27 April and 3 May 2020 (corresponding with the early and late phases of the first national lockdown in Portugal, respectively), this study explored concerns and coping mechanisms of the general public. Responses with similar meanings and connotations were inductively synthesised into exhaustive and mutually exclusive categories after *a priori* coding.<sup>6</sup> As comments from an individual may include more than one concern or coping mechanism, responses could be coded into several separate categories, with each idea belonging to only one category. Sociodemographic characteristics of the study participants are summarised in Table S1 in the supplementary material.

**Results**

*Concerns*

Participants mainly expressed negative emotions in both the early and late phases of the first lockdown (see Table 1). Participants reported fear of losing close relatives and of contracting/spreading the virus, as well as fear of using healthcare services or entering indoor public spaces (particularly shops), along with feelings of anxiety towards individuals with symptoms, suspected, infected or exposed to COVID-19. There was also the expression of negative feelings towards the future.

Experiencing vulnerabilities regarding oneself and others constituted an additional topic of concern. Participants mentioned the negative impact of the pandemic on their mental health and how the lack of physical contact with family members and friends was difficult. They also perceived vulnerabilities regarding their children/grandchildren, mainly related to their academic/professional careers and health (physical and mental), highlighting the need to prioritise children’s well-being and to invest in children’s psychological support. Some participants voiced concerns related to an increase in social inequality, discrimination and stigmatisation. In addition, a few participants referred to the loss of individual freedom and autonomy resulting from constant surveillance and sanitation and cleaning of bodies and spaces.

The economic crisis and the wide dissemination of information about COVID-19 were perceived as challenging and difficult situations for society. Worries about job loss and decreasing household incomes were prominent. Respondents frequently expressed concerns related to working remotely from home and the additional stress of having to take care of children and other dependent individuals or feeling that productivity was hampered by adverse working conditions at home. Another issue concerning participants was the lack of consistency in the information conveyed to citizens by the government and the media, as well as the negativity in the news. Participants requested readily available information for people with health conditions who might be at increased risk during the pandemic and urged for increased collaboration among the scientific community.

Participants were also concerned about others not complying with government measures, particularly rules on physical distancing and face coverings. There were reports of non-compliance among

**Table 1**  
Concerns and coping mechanisms reported by the participants during the first COVID-19 lockdown in Portugal.

Concern/coping mechanism	Number of statements			
	Concerns		Coping mechanisms	
	Early phase	Late phase	Early phase	Late phase
Emotions				
Negative emotions	190	63		
Positive emotions			68	25
Perceiving/experiencing crisis				
Perceiving vulnerabilities in oneself/others	106	59		
Perceiving a challenge for society	86	30		
Perceiving privileges for oneself			31	8
Practices				
Changing practices			67	34
Supporting practices			35	11
Protecting practices			6	5
Maintaining routines			7	10
Relationship to institutions				
Self-compliance with government measures			407	224
Trust towards institutions			15	19
Others are not complying with government measures	70	39		
Criticising/doubts/sceptic towards government policy	62	43		
Efficiency and reliability of the healthcare system	44	13		



close relatives, the general population and employers who did not allow their employees to work remotely from home or waived the measures recommended in the workplace.

Comments that expressed criticism, scepticism or doubts towards government policy increased over time. Participants highlighted the situations in elderly care homes, social centres and prisons and in the construction work sector. Some participants referred to the scarcity of resources to carry out inspection, policing and enforcement in public and semipublic spaces, including public transport. Several participants mentioned the need to carry out more screening tests and to guarantee the availability of personal protective equipment for the entire population.

Statements about the perceived efficiency and reliability of the healthcare system covered two main concerns. First, focussing on the pandemic could impair the management of other diseases, care during pregnancy and compliance with the national immunisation programme. Second, participants reported delays in feedback from the national health service phone line and in performing COVID-19 tests, absence of a reply from primary care centres, misguidance about referrals/exams, institutional overlapping, and increased vulnerabilities of migrants and disabled people.

### *Coping mechanisms*

Contrasting with concerns about non-compliance by others, self-compliance with government measures emerged as the main coping mechanism. Participants reported establishing personal contacts, travelling only for justifiable reasons (e.g. professional practice, social/family support, health issues and essential goods/services) and the use of self-protective equipment and masks.

Another coping strategy reported by the participants was changing practices, namely, greater investment in home-based leisure activities, the use of social media to communicate with family and friends and online services to purchase essential goods or to contact institutions or companies, the adoption of healthier lifestyles and selection of information about COVID-19 to feel informed without saturation. Several participants reported supporting practices (including providing and receiving functional and emotional support, as well as the maintenance of daily routines) and engaging in protecting practices (e.g. using medically prescribed drugs or seeking out psychological support services and feeling protected by their employer).

The practice of these coping mechanisms was linked with expressions of positive emotions. The manifestation of hope was based on examples of solidarity, cases of people recovering from COVID-19, faith, patience, resilience and the removal of negative thoughts.

Perceiving privileges for oneself (e.g. the possibility of resorting to a second home) and trust towards institutions (e.g. health care, political institutions, police forces and the scientific community) were less frequently mentioned coping mechanisms.

### **Discussion**

Data suggest the prominence of behavioural and emotional responses to COVID-19, namely, self-compliance with government measures, adopting practices of self-care and supporting/protecting others and enacting hope. These results are in line with previous evidence.<sup>7</sup> Concerns were related to the perception of vulnerabilities for oneself, family and others and challenging situations for society (physical and mental health, academic/professional careers, income, social inequality, potential discrimination and stigmatisation, inconsistent information, and negative approach to the news), coupled with criticism, scepticism or doubts towards government policy and the perceived efficiency and reliability of the healthcare

system, as previously observed.<sup>8</sup> Expressions of negative emotions, such as fear and worry, and others (e.g. close relatives, employees and the general population) not complying with government measures emerged as additional sources of anxiety.<sup>9</sup> The results from this study promote positive actions by governments to face future pandemics by adding a culturally sensitive perspective from Portugal to promote the strengthening of social ties, empathy and solidarity at interpersonal, group and contractual levels.<sup>6</sup>

Although this study lacks the generalisability of a representative sample of the Portuguese population, the results may indicate the general concerns and coping mechanisms of Portuguese people with higher levels of education and household incomes, mainly women.

Knowledge about the prevailing concerns and coping mechanisms facilitates the development of targeted actions of risk communication to enhance public awareness and compliance. In turn, risk communication and effective, yet acceptable, infection containment strategies should be produced in collaboration with the wider public.<sup>10</sup> Further research on the views of the general public and continuous assessment of behavioural and emotional responses of the population to restrictions imposed as a result of the COVID-19 pandemic are required.

### **Author statements**

#### *Ethical approval*

This study was approved by ISPUP Ethics Committee (CE20142).

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#### *Competing interests*

None declared.

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### **Appendix A. Supplementary data**

Supplementary data to this article can be found online at [10.1016/j.puhe.2022.03.014](https://doi.org/10.1016/j.puhe.2022.03.014).

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## Letter to the Editor

## COVID-19 and global mental health service delivery and financing



The COVID-19 pandemic has taken a significant toll on people's mental health. Since March 2020, the prevalence of both major depressive and anxiety disorders has doubled and even tripled in some European countries.<sup>1</sup> A similar pattern was found in many low- and middle-income countries (LMICs). In comparison to high-income countries, LMICs have a higher prevalence of comorbidities with less available universal healthcare and social support systems.<sup>2</sup> As the world enters into the third year of the COVID-19 pandemic, the mental health aftermath of this global crisis will likely prove long, compounding and deepening the impacts of social and economic disruptions that were already underway before the pandemic.

The mental health pandemic is a multifaceted problem with various causes. COVID-19 has claimed more than 6 million lives globally, and the actual death toll is likely higher than the reported number. The loss of lives imposes widespread grief and suffering on affected individuals and communities. This grief can lead to longer term mental health conditions without proper care and support. The COVID-19 virus is associated with neurological manifestations that can contribute to mental health issues.<sup>3</sup> The implementation of strict disease control measures (e.g. school closures, social distancing, and isolation periods) can greatly increase levels of stress and disrupt usual coping mechanisms and social supports.<sup>4</sup> Amplified feelings of loneliness, isolation, and stress are strongly associated with anxiety, depression, and insomnia. In addition, the pandemic induced economic recessions in many countries and drove small and large enterprises out of business, which affected the daily life of numerous households. The resultant financial insecurity introduced significant mental health concerns. Meanwhile, the pandemic has interfered with the delivery of routine, in-person mental health, and psychosocial support services. A study reported that 93% of countries had disruptions in mental health services.<sup>5</sup>

Recognizing increasing demand for mental health and psychosocial support (MHPSS) services while facing the disruptions, countries have developed various strategies to facilitate the delivery of MHPSS services. The strategies span from detecting mental health problems to delivering mental health care, from raising awareness of available mental health support among the general population to providing training in mental health care for health and/or non-health professionals.<sup>5</sup> Clearly, digital health has vastly expanded in many countries. Artificial intelligence was deployed to help detect budding mental health issues and alert patients to seek care, and on-line consultations became a popular way to deliver cognitive behavioral therapy for mental health disorders.<sup>6</sup> Despite these advances, there were growing concerns about equity and access to care in rural areas where access to technology is sparse. To combat this, community health workers were trained to deliver basic psychosocial

support and conduct home visits, whereas helplines were introduced/reintroduced to provide basic mental health consultations in some limited-resource settings.<sup>5</sup> These strategies, to some degree, reduced the mental health service gap that would have been even larger during the pandemic.

Sustaining the delivery of routine and innovative mental health services requires significant financial support. However, global investments in mental health have been disproportionately low. Only an average of 2% of total health spending is on mental health globally, compared with 12% of the total disease burden due to mental health disorders.<sup>7</sup> Even in humanitarian settings (e.g. forcibly displaced populations), where people are particularly vulnerable to mental health risks, the funding for mental health is scarce. The pandemic has clearly raised the awareness of global mental health investments among international donors and domestic health systems. The donor community has begun investing specifically in mental health in recipient countries. Mental health support was put to the forefront to help communities adjust to the pandemic in the COVID-19 response funded by the United States Agency for International Development.<sup>8</sup> The World Bank, one of the largest funders of the COVID-19 response in LMICs, initiated programs that directly supported psychosocial interventions to address psychological problems during the pandemic,<sup>9</sup> besides its commitment in calling for reimagined primary health care to integrate MHPSS services and in supporting countries' actions toward this direction.<sup>10</sup> Domestically, the national COVID-19 emergency response plans in many countries added mental health support as a critical component in mitigating the short- and long-term effects of the pandemic, although the financial commitment to ensure the delivery of mental health services remains uncertain.<sup>5</sup>

As new innovations for delivering mental health services emerge and mental health investments increase, it is critical for governments, with donors' support, to enhance mental health service delivery and financing and to leverage investments across sectors as part of building a more inclusive and resilient post-pandemic health system. Integrating mental health initiatives into both international and national emergency response strategies and public health strategies serves as a good start.

#### Disclaimer

The views expressed in this letter are those of the authors, and no official endorsement by their respective organizations.

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## Short Communication

# First-generation BNT162b2 and AZD1222 vaccines protect from COVID-19 pneumonia during the Omicron variant emergence

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## ABSTRACT

**Objective:** This study aimed to identify factors predicting pneumonia in adults with coronavirus disease 2019 (COVID-19) during the Omicron variant (B.1.1.529) emergence. We also evaluated, in fully vaccinated (BNT162b2 or AZD1222) individuals, if the time (<6 or ≥6 months) elapsed since the last shot was received was associated with the risk of severe illness.

**Study design:** A retrospective cohort study was conducted in Mexico.

**Methods:** Data from 409,493 were analyzed, and risk ratios (RRs) and 95% confidence intervals (CIs) were computed through generalized linear models.

**Results:** We documented a total of 3513 COVID-19 pneumonia cases (69.5 per 100,000 person-days). In multiple analyses, a protective effect was observed in vaccinated adults (RR = 0.996, 95% CI 0.995–0.997). Male gender, increasing age, and smoking were associated with a greater risk of pneumonia. Individuals with chronic comorbidities (pulmonary obstructive disease, type 2 diabetes mellitus, arterial hypertension, kidney disease, and immunosuppression) were also at higher risk. Among fully vaccinated subjects ( $n = 166,869$ ), those who had received the last shot at 6 more months were at increased risk for developing pneumonia (RR = 1.002, 95% CI 1.001–1.003).

**Conclusions:** Our results suggest that the first-generation BNT162b2 and AZD1222 vaccines reduce the risk of COVID-19 pneumonia during the Omicron emergence. We also found that adults with longer interval from the administration of the second shot to illness onset were at increased risk of severe manifestations.

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## Introduction

The B.1.1.529 (Omicron) variant from the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first identified in South Africa in early November 2021. Since this variant has been shown higher transmission rates than previous circulating variants, it rapidly became dominant all around the globe,<sup>1</sup> and it peaked in Mexico between December 2021 and January 2022.<sup>2</sup>

The BNT162b2 (Pfizer, Inc./BioNTech) and AZD1222 (AstraZeneca) have been widely used in Mexico since the last bimester of 2020. When compared with the Delta variant, reduced vaccine effectiveness has been documented in fully vaccinated individuals against the Omicron infection.<sup>3,4</sup> Therefore, concerns have arisen regarding the impact of current vaccines on COVID-19 pneumonia prevention and reduction in hospital utilization. This study aimed to identify factors predicting COVID-19-related pneumonia in adults during the Omicron variant emergence. In addition, we evaluated if the time elapsed since the last COVID-19 vaccine shot received was associated with the risk of developing pneumonia in a subset of fully vaccinated subjects.

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**Methods**

We performed a nationwide retrospective cohort study in Mexico during the first bimester of 2022. Subjects aged ≥18 years, with laboratory-confirmed (reverse transcription-polymerase chain reaction or antigen-based testing in nasopharyngeal swabs) COVID-19 and symptoms onset from December 2021 to January 2022 were eligible. A broader description of the used laboratory methods was previously published.<sup>5</sup>

Eligible participants were identified from the nominal records of a normative and national system of the epidemiological surveillance of respiratory viral pathogens, which primary data sources are the medical files and, if applicable, death certificates. This system is called Online Notification System for Epidemiological Surveillance (SINOLAVE, the Spanish acronym) and belongs to the Mexican Institute of Social Security (IMSS, the Spanish acronym), which provides healthcare and social services to more than 83 million users all across the country.

Patients with missing clinical or epidemiological data of interest and those who received other COVID-19 vaccines than BNT162b2 or AZD1222 were excluded.

Vaccinated adults were those two shots of BNT162b2 or AZD1222. Unvaccinated participants were those who had not received any COVID-19 vaccine dose from any pharmaceutical company. The interval (months) between the last vaccine shot was received, and the date of symptoms onset was computed and dichotomized (<6 or ≥6 months).

The main binary outcome (no/yes) was pneumonia due to COVID-19, and it was defined by clinical and radiographic findings that required hospital admission. Clinical and epidemiological data of interest, as well as the COVID-19 vaccination status and dates of their administration, were retrieved from the audited surveillance system.

We used generalized linear regression models to compute risk ratios (RRs) and 95% confidence intervals (CIs). Two multiple regression models were built. The first model was used to evaluate predictors of COVID-19 pneumonia during the Omicron emergence; the latter one evaluated the effect of the time elapsed since the last vaccine shot with the risk of pneumonia in fully immunized subjects.

**Results**

Data from 409,493 laboratory-confirmed cases of COVID-19 were analyzed. The mean age (± standard deviation) of participants was aged 39.0 ± 13.3 years, and most of them were female (56.1%). The total follow-up was 5,052,192 person-days, and 3513 cases of COVID-19 pneumonia were registered (69.5 per 100,000 person-days). A fatal outcome was documented in one-third (33.8%) of patients with severe manifestations.

The vaccinated group was integrated by 166,869 participants (40.8%), and AZD1222 was administered in most of them (60.7%). Table 1 shows the characteristics of the study sample for the analyzed variables. Pneumonia patients were more likely to be

**Table 1**  
Predictors of pneumonia in laboratory-confirmed cases of COVID-19 (n = 409,493) during the Omicron variant emergence, Mexico 2021–2022.

Characteristic	Pneumonia (n)			Bivariate analysis			Multiple analysis		
	no	/	yes	RR	(95% CI)	P	RR	(95% CI)	P
<b>Sex</b>									
Female	227,962	/	1583	1.000			1.000		
Male	178,018	/	1930	1.004	(1.003–1.005)	<0.001	1.002	(1.001–1.003)	<0.001
<b>Age group (years)</b>									
18–39	236,874	/	401	1.000			1.000		
40–59	144,697	/	969	1.005	(1.004–1.006)	<0.001	1.002	(1.001–1.003)	<0.001
≥60	24,409	/	2143	1.082	(1.079–1.086)	<0.001	1.065	(1.062–1.068)	<0.001
<b>COVID-19 vaccination status <sup>a</sup></b>									
Unvaccinated	240,145	/	2479	1.000			1.000		
Vaccinated	165,835	/	1034	0.996	(0.995–0.997)	<0.001	0.996	(0.995–0.997)	<0.001
<b>Personal history of:</b>									
<b>Obesity</b>									
No	240,145	/	2479	1.000			1.000		
Yes	165,835	/	1034	1.008	(1.006–1.009)	<0.001	1.001	(0.998–1.002)	0.620
<b>Smoking (current)</b>									
No	389,275	/	3222	1.000			1.000		
Yes	16,705	/	291	1.009	(1.007–1.011)	<0.001	1.001	(1.004–1.007)	<0.001
<b>Chronic pulmonary obstructive disease</b>									
No	404,561	/	3317	1.000			1.000		
Yes	1419	/	196	1.120	(1.102–1.138)	<0.001	1.058	(1.042–1.075)	<0.001
<b>Type 2 diabetes mellitus</b>									
No	384,050	/	2261	1.000			1.000		
Yes	21,930	/	1252	1.049	(1.046–1.052)	<0.001	1.018	(1.015–1.021)	<0.001
<b>Arterial hypertension</b>									
No	371,552	/	1864	1.000			1.000		
Yes	34,428	/	1649	1.042	(1.039–1.044)	<0.001	1.012	(1.010–1.015)	<0.001
<b>Chronic kidney disease (any stage)</b>									
No	403,438	/	3020	1.000			1.000		
Yes	2542	/	493	1.168	(1.152–1.183)	<0.001	1.119	(1.105–1.134)	<0.001
<b>Immunosuppression <sup>b</sup></b>									
No	404,590	/	3387	1.000			1.000		
Yes	1390	/	126	1.078	(1.063–1.093)	<0.001	1.037	(1.023–1.052)	<0.001

RR, risk ratios; CI, confidence interval.

(1) Generalized linear regression models were used to obtain the presented estimates; (2) RR and 95% CI from the multiple analysis were adjusted by the variables presented in the table.

<sup>a</sup> Vaccinated adults were those two shots of BNT162b2 (Pfizer, Inc./BioNTech) or AZD1222 Covishield (AstraZeneca); unvaccinated participants were those who had not received any COVID-19 vaccine dose from any pharmaceutical company.

<sup>b</sup> Any cause (excepting type 2 diabetes mellitus).

male and to be older than mild cases ( $P < 0.001$ ). Patients with severe illness were also more likely to be unvaccinated or to present any comorbid condition ( $P < 0.001$  in all of them).

In the first multiple regression model (Table 1), fully vaccinated subjects had a reduced risk of pneumonia (RR = 0.996, 95% CI 0.995–0.997). Male gender (RR = 1.002, 95% CI 1.001–1.003), increasing age (vs 18–39 years old: 40–59, RR = 1.002, 95% CI 1.001–1.003; 60 or older, RR = 1.065, 95% CI 1.062–1.068), as well as all the analyzed comorbidities (except for obesity), were also associated with an increased risk of COVID-19-related pneumonia. The greatest risk was conferred by the personal history of chronic kidney disease (any state; RR = 1.134, 95% CI 1.108–1.160).

In fully vaccinated adults (please see the Supplementary data 1), we documented that participants with a longer interval from the last vaccine shot and illness onset (6 or more months) had a slight but significantly reduced risk for developing severe illness (vs <6 months: RR = 1.002, 95% CI 1.001–1.003). This estimate was adjusted by host factors. When compared with the rest of the estimates from the first model, no major changes were observed in the ratios from the latter one.

## Discussion

We characterized factors predicting pneumonia due to laboratory-confirmed COVID-19 in a large subset of adults during the Omicron emergence in Mexico. Our results suggest that even though this variant can evade neutralizing antibodies, the first-generation BNT162b2 and AZD1222 vaccines reduce the risk of developing pneumonia in fully immunized adults. Otherwise, we observed that host factors, such as gender, age, and chronic medical conditions, are associated with an increased risk of severe illness. If later replicated, these findings would highlight the relevance of promoting healthy lifestyles and immunization in eligible subjects to reducing the pandemic burden.

In our study, patients who had received the last vaccine shot at 6 or more months were at greater risk of developing pneumonia (vs <6 months: 1.002, 95% CI 1.001–1.003). This is consistent with previously published data where a decrease in anti-spike IgG and neutralizing antibodies were evidenced after 6 months of the BNT162b2 vaccine administration.<sup>6</sup>

We analyzed the BNT162b2 and AZD1222 vaccines because they had been broadly administered in Mexico. By February 7, 2022, about 51.5 and 90.6 million doses of BNT162b2 and AZD1222 had been received in our country.<sup>7</sup> When we evaluated the specific effect of each of these biological products on the risk of pneumonia, similar estimates were observed in both of them (BNT162b2,  $n = 65,565$ ; AZD1222,  $n = 101,304$ ). The same was documented when the interval between the last vaccine shot and illness was evaluated.

Another aspect that must be highlighted is that most of the identified COVID-19 cases during the study period had mild symptoms, and pneumonia was observed in around 8 out of 1000 laboratory-positive cases. This is related to the smaller virulence of Omicron when compared with previous variants.<sup>8</sup> The pneumonia rate in our analysis is much lower than the observed during previous variant emergences in the same study setting, which was around 30%.<sup>9</sup> A fatal outcome was documented in nearly one-third (33.8%) of the enrolled individuals. Therefore, the case fatality rate in the study sample was 29.0 per 10,000.

The potential limitations of this study must be discussed. First, according to normative standards, the genomic sequencing is not performed in all laboratory-positive COVID-19 cases. Therefore, we are unable to ensure that all the analyzed participants were infected by the Omicron variant. However, we consider that most of these infections correspond to the variant of interest given (1) the documented peak in the incidence of COVID-19 in Mexico during

the study period (please see the Supplementary data 2) and (2) in the United States, and also during the end of 2021 or start of 2022, the Omicron variant was identified in nearly 99% of genomic sequences.<sup>10</sup> Second, vaccine booster began to be applied to the general population during January 2022 in high-risk population, so a small fraction of participants may have had it at the time of symptoms onset. These data were not collected by the audited surveillance system at the time of recruitment.

## Conclusions

Our results suggest that during the Omicron variant emergence, the first-generation BNT162b2 and AZD1222 COVID-19 vaccines are effective in reducing the risk of pneumonia. We also found that participants with a shorter interval between the second shot and illness onset were at reduced risk of severe manifestations. If later replicated, these findings may provide additional data to support the administration of a third vaccine shot to reduce the pandemic-related burden.

## Author statements

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This study was reviewed and approved by the Committee of Ethics in Health Research (601) of the IMSS (approval R-2020-601-022).

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### Competing interests

None declared.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2022.04.001>.

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## Original Research

# How arts engagement supported social connectedness during the first year of the COVID-19 pandemic in the United Kingdom: findings from the HEartS Survey



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## ABSTRACT

**Objectives:** This study investigated how adults in the United Kingdom perceived their arts and cultural engagement to facilitate social connectedness over two phases in the first year of the COVID-19 pandemic.

**Study design:** The study used the HEartS Survey, a newly designed online survey tool to capture arts engagement in the United Kingdom and its associations with social and mental well-being, over two phases in 2020: March to May (Phase 1) and October (Phase 2).

**Methods:** Qualitative data were provided at both phases by 581 respondents, who identified which arts and cultural activity they felt most connected them to others and how during the last month.

**Results:** Thematic analysis revealed that, at both phases, arts and cultural engagement was perceived to facilitate social connectedness through four pathways that were also identified prepandemic: social opportunities, sharing, feelings of commonality and belonging and collective understanding. The sub-themes shed light on specific ways that respondents used the arts during the pandemic to connect with others, including using the arts: as a catalyst for conversations, to maintain, reinstate or strengthen relationships during social distancing and to facilitate social interactions (Theme 1); to bring people together through shared experiences and sharing of art (Theme 2); to elicit feelings of direct and indirect proximity to others, to connect people with common interests, to feel a sense of belonging to something and to feel part of a collective 'COVID-19 experience' or to feel collectively distracted from the pandemic (Theme 3); and to learn from and about other people and to relate to others (Theme 4). The activity most frequently cited as connecting was watching a film or drama, followed by listening to recorded music.

**Conclusions:** Engagement in arts and cultural activities supported feelings of social connection among adults in the United Kingdom over two phases in the first year of the COVID-19 pandemic, highlighting the importance of access to the arts and culture to support social connectedness.

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## Introduction

Social connectedness reflects how connected, or distant, people feel from other individuals and society.<sup>1</sup> It encompasses caring for others, being cared for and feeling a sense of belonging and can be determined by social network and life satisfaction.<sup>2</sup> During the COVID-19 pandemic, many channels for social connections—such

as social events—became unavailable, with the reduction or loss of in-person interactions contributing to loneliness.<sup>3</sup> Indeed, according to the Office for National Statistics, loneliness levels have increased in the United Kingdom since Spring 2020,<sup>4</sup> with more than one-third of adults in the United Kingdom reporting sometimes or often feeling lonely during the pandemic.<sup>5</sup>

It has been suggested that social connectedness is the 'opposite of loneliness',<sup>2</sup> that it could potentially reduce loneliness,<sup>6</sup> and that public health messaging should include approaches that promote social connection to address issues of loneliness.<sup>7</sup> Our previous, prepandemic, research indicated that engagement with the arts

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and culture can support perceived social connectedness. Eighty-two percent of a sample of 5892 adults in the United Kingdom, closely matched to the national profile in terms of sociodemographic and economic characteristics, perceived their engagement with the arts to be linked with feelings of social connectedness at least some of the time, with the arts seen to facilitate social opportunities, sharing, feelings of commonality and belonging and collective understanding.<sup>8</sup> Other prepandemic research also reports that participatory arts can support social connections, particularly among older adults.<sup>9,10</sup>

Prepandemic, arts activities most cited as socially connecting were *in-person* activities at *out-of-the-home* venues: attending a live music performance, watching a live theatre performance and watching a film or drama at the cinema or other venue.<sup>8</sup> The initial lockdown in the United Kingdom, however, led to the closure of venues, with access continuing to be restricted by social distancing through 2020. This leaves open the question of whether the arts continued to support feelings of social connectedness during the pandemic. Research has indicated that at-home arts activities, such as digital arts and writing, music, crafts and reading, were used to help cope with emotion and to support self-development during COVID-19,<sup>11</sup> but less is known about how such activities might support social connectedness. This study therefore investigates how, if at all, arts and cultural engagement was perceived to facilitate feelings of social connectedness over two phases in the first year of the pandemic in the United Kingdom.

## Methods

Data were collected via the *HEarts Survey* (Health, Economic and Social impacts of the ARTs), designed to capture current arts and cultural engagement in the United Kingdom and to explore its sociodemographic characteristics and correlations with mental and social well-being.<sup>12,13</sup> The *HEarts Survey* consists of seven sections: (1) demographics; (2) frequency and nature of arts and cultural activities, widely defined to include informal, at-home activities; (3) open questions on arts and social connectedness; (4) mental well-being; (5) physical activity; (6) social well-being; and (7) household income and arts spending.<sup>12</sup>

Data were drawn from two questions in section 3: Q1. 'Of the arts and cultural activities you have told us about [earlier in the survey], which makes you feel most connected to other people? (Please select just one activity) (drop-down choice of all arts activities)'; Q2. 'In view of the current public health situation, why has this activity made you feel connected to other people during the last month? Please write in as much detail as possible and include examples or stories where appropriate (open response)'. Using skip logic, respondents only answered these questions if they had previously indicated that their engagement with arts and cultural activities did help them to feel connected with other people (see 'Respondents'). Data from sections 1 and 7 were used to report sample demographics, and prepandemic data on these questions are published elsewhere.<sup>8</sup>

## Respondents

Respondents were recruited to complete the *HEarts Survey* through an online data collection platform, Qualtrics, over two phases in the first year of the pandemic in the United Kingdom: March to May 2020 (Phase 1) and October 2020 (Phase 2). This study focuses on a subset of respondents who provided qualitative data in response to Q2 at *both* phases, allowing us to explore how, if at all, perceptions of how the arts support social connections changed over the course of 2020.

At Phase 1, a total of 10,513 respondents completed the survey. Data collection quotas were set for gender, age, geographical region, ethnicity and education following the overall distributions of these key sociodemographic variables in the UK 2011 Census.<sup>12</sup> 3647 respondents completed the surveys at both Phase 1 and at Phase 2. Of these, 1291 had not engaged in arts or cultural activities at Phase 1. Of the remaining 2356 respondents who had engaged in arts or cultural activities, 1753 (74.4%) reported that these helped them to feel connected with other people at least a little (on a scale from 'always' to 'not at all'). Of these 1753 respondents, 581 provided a usable response (nonsense or clearly off-topic responses were removed) to Q2 at both phases and therefore constitute the study sample (see [Table 1](#)).

Ethical approval was granted by the Conservatoires UK Research Ethics Committee on 22 March 2020. All respondents who completed the survey were paid a modest fee via the Qualtrics platform.

## Analysis

Analysis of qualitative data was undertaken using a largely descriptive form of thematic analysis, closest to what Braun and Clarke describe as a 'codebook' approach.<sup>14</sup> Our starting point was to use the codebook developed in our prepandemic analysis,<sup>8</sup> with two authors (S.L.K. and B.B.Z.) deductively analysing the data across the two phases. Concurrently, and in discussion with a third author (R.P.), the two authors identified (1) new subthemes that were not covered in the existing codebook and (2) sub themes that were present in the codebook but that were nuanced in response to the pandemic and therefore required an updated description. Second, the two authors cross-checked and confirmed each other's analysis across the two phases. Finally, R.P. cross-checked the full codebook. The final themes served as 'topic summaries'<sup>14</sup> allowing us to describe how, if at all, arts and cultural engagement was perceived to facilitate feelings of social connectedness during the first year of the pandemic in the United Kingdom. Descriptive statistics were used to describe the sample and arts engagement using jamovi.<sup>15</sup> Further analyses from the *HEarts Survey* are documented elsewhere.<sup>8,12</sup>

## Results

Of the Phase 1 respondents, 366 (63%) reported that arts engagement helped them to feel socially connected 'a little', 74 (12.7%) reported 'around half the time', 118 (20.3%) reported 'often' and 23 (4%) reported 'always'. At Phase 2, 365 (62.8%) respondents reported 'a little', 57 (9.8%) reported 'around half the time', 131 (22.5%) reported 'often' and 28 (4.8%) reported 'always'. [Table 2](#) details the arts activities reported as most connecting across the two phases. Consistently, the activity most frequently cited was watching a film or drama, followed by listening to recorded music.

The qualitative analysis revealed the same main themes as reported prepandemic,<sup>8</sup> indicating that the arts have continued to support feelings of social connectedness in the same broad ways during COVID-19. Ten subthemes reveal the COVID-specific nature of respondents' experiences across both periods of data collection, as detailed in [Table 3](#).

### *Theme 1. Facilitating social opportunities*

Across the two phases, respondents identified that arts engagement facilitated social opportunities. The first subtheme (1.1) captures the role of the arts in providing a catalyst for arts-related conversations:

**Table 1**  
Sample characteristics.

Sociodemographic and economic characteristics (N = 581)	n	%
<b>Age</b>		
Total sample (mean, SD)	47.60	15.8
18–25	58	10.0
26–35	104	17.9
36–45	95	16.9
46–55	129	22.2
56–65	108	18.6
66–75	80	13.8
76–94	7	1.2
<b>Gender</b>		
Women	284	48.9
Men	297	51.1
Would rather not say	0	0
Other	0	0
<b>Region</b>		
Northern Scotland	10	1.7
Southern Scotland	31	5.3
North East	19	3.3
North West	65	11.2
Yorkshire and the Humber	51	8.8
East Midlands	42	7.2
West Midlands	45	7.7
East of England	65	11.2
South East	78	13.4
South West	55	9.5
London	77	13.3
North Wales	9	1.5
South Wales	18	3.1
Northern Ireland	16	2.8
<b>Ethnicity</b>		
White British or Irish	515	88.6
Any other White background	18	3.1
Mixed ethnic backgrounds <sup>a</sup>	15	2.6
Asian ethnic backgrounds <sup>a</sup>	18	3.1
Black ethnic backgrounds <sup>a</sup>	12	2.1
Any other ethnic background	3	0.5
<b>Education</b>		
No formal qualification	6	1.5
Other vocational and foreign qualifications	37	6.4
GCSE, O Level, AS Level – NVQ Level 1–2	118	20.3
A level, baccalaureate – NVQ Level 3	154	26.5
University degree – NVQ Level 4–5	266	45.8
Would rather not say	0	0
<b>Living status</b>		
Lone living	104	17.9
With partner only	210	36.1
With children, with or without partner/others	189	32.5
With family, house share and other	78	13.4
Would rather not say	0	0
<b>Household income</b>		
Up to £5199	10	1.7
£5200 and up to £10,399	25	4.3
£10,400 and up to £15,599	44	7.6
£15,600 and up to £20,799	39	6.7
£20,800 and up to £25,999	64	11.0
£26,000 and up to £31,199	74	12.7
£31,200 and up to £36,399	45	7.7
£36,400 and up to £41,599	50	8.6
£41,600 and up to £46,799	30	5.2
£46,800 and up to £51,999	43	7.4
£52,000 and up to £75,999	89	15.3
£76,000 and above	62	10.7
Would rather not say	6	1.0

<sup>a</sup> Ethnicity: any mixed background includes White and Black Caribbean, White and Black African, White and Asian and any other mixed background; any Asian background includes Indian, Pakistani, Bangladeshi, Chinese or any other Asian background; any Black background includes Caribbean, African and any other Black background.

I am able to take time out of my life and relax with others while watching a movie. I am then able to talk about the film with these people. [Phase 1, watched a film or drama].

I have spent more time talking to my daughters on the phone about crafts. They asked me to make them some decorative pumpkins for Halloween, which is something I would not otherwise have done. [Phase 2, any form of crafts].

Importantly, the arts also functioned as means of maintaining, reinstating and strengthening relationships during social distancing (subtheme 1.2). Data were only coded to this subtheme if they explicitly referenced the maintenance or enhancement of existing relationships:

I am a member of a semi-professional choir. Rehearsing in person is not possible and online is not practical. Staying in touch with others by pre learning new pieces at home helps us to stay in touch. [Phase 1, played a musical instrument or sang].

Drawing has allowed me to bond with my daughters, I feel like we connect as my daughters are spending time with me while having fun and learning. [Phase 2, painting, drawing, print-making, sculpture, etc.]

Finally, arts activities also supported people in general socialising and interaction with others (subtheme 1.3):

[It] keeps you socially active even if just online. [Phase 1, any type of crafts].

I am learning to play the bagpipes, and every day unless it is absolutely pouring down, I walk my pipes, playing in the local woods and fields. I am well known in my area as “The Bagpipe Man” and normally I meet a number of people, mostly dog walkers, and we pass the time of day. [Phase 2, played a musical instrument or sang].

This general interaction, based on socialising, was differentiated analytically from specific arts-related conversations (1.1) and from maintaining or strengthening relationships (1.2), although in practice, there may of course be overlap in how the arts were used to support social opportunities.

*Theme 2. Facilitating sharing*

At both phases, respondents reported that the arts bring people together through shared experiences. Subtheme 2.1 captures the perception that the arts can facilitate quality time spent together through the medium of a shared activity: It’s just something that I get to share with my family; something we can do together without having to go out anywhere. [Phase 1, watched a film or drama].

I feel that it is a moment that is shared:

It’s something we enjoy doing together. It brings us together, and we make the most of the time and you feel a connection through the music. [Phase 2, listened to recorded music].

Importantly, this subtheme reflects connectedness through shared participation in an arts activity, rather than the more socially oriented interactions afforded by or around arts activities captured in Theme 1. For some respondents, the act of creating and then sharing art also created a sense of connection with others (subtheme 2.2):

**Table 2**  
Forms of arts engagement most linked with feelings of social connectedness across two phases in 2020.

Of the arts and cultural activities you have told us about, which makes you feel most connected to other people? (N = 581)	Phase 1, n	Phase 1, %	Phase 2, n	Phase 2, %
Watched a film or drama	151	26.0	153	26.3
Listened to recorded music	85	14.6	88	15.1
Played a musical instrument or sang	45	7.7	35	6.0
Read as a past-time activity	41	7.1	40	6.9
Attended live music	36	6.2	18	3.1
Done any form of crafts	34	5.9	31	5.3
Done photography, film, video making, etc.	33	5.7	34	5.9
Listened to audio books or podcasts	31	5.3	34	5.9
Done painting, drawing, printmaking, sculpture, etc.	30	5.2	21	3.6
Written as a past-time activity	17	2.9	17	2.9
Practised, rehearsed or performed dance	16	2.8	16	2.8
Attended live theatre or circus	16	2.8	8	1.4
Attended an exhibition, museum, collection of art, etc.	12	2.1	31	5.3
Attended a book club	10	1.7	10	1.7
Other	6	1.0	11	1.9
Attended an event connected with books or reading	4	0.7	5	0.9
Attended live dance	4	0.7	2	0.3
Written or created music	3	0.5	4	0.7
Attended a convention, show, fair relating to crafts etc.	3	0.5	3	0.5
Seen street art, public art displays, etc.	3	0.5	14	2.4
Practised, rehearsed or performed a play, drama, etc.	1	0.2	6	1.0

**Table 3**  
Summary of themes for how arts engagement was perceived to facilitate feelings of social connectedness during two phases in 2020.

Themes and (sub)subthemes	Description	Instances Phase 1	Instances Phase 2
<b>1. Facilitating social opportunities</b>	<b>The arts facilitate social opportunities</b>		
1.1 Conversing about art	The arts act as a catalyst for conversations	140	138
1.2 Maintaining/strengthening relationships	The arts allow people to maintain, reinstate and strengthen relationships during social distancing	62	46
1.3 Socialising and interacting with others	The arts encourage and facilitate new and/or generalised social interactions	56	81
<b>2. Facilitating sharing</b>	<b>The arts facilitate opportunities for shared experiences</b>		
2.1 Sharing arts experiences	The arts bring people together through shared experiences	124	148
2.2 Sharing art with others	When people share their art, it creates a sense of connection between them and others	71	62
<b>3. Facilitating commonality and belonging</b>	<b>The arts facilitate feelings of closeness, similarity and belonging</b>		
3.1 Enabling proximity to others	The arts elicit feelings of direct and indirect proximity to others, sometimes via proxy	148	127
3.2 Connecting through common interests	The arts connect likeminded people with common interests	36	61
3.3 Being part of something	The arts allow people to feel part of, and belonging to, something bigger than themselves	29	22
3.3.1 Collective COVID experience	The arts allow people to feel part of a collective 'COVID-19 experience'	22	13
3.3.2 Grounding experience	The arts provide collective distraction/escapism from, or a sense of normality, during COVID-19	22	40
<b>4. Facilitating collective understanding</b>	<b>The arts facilitate learning from and about other people</b>		
4.1 Knowledge exchange	The arts allow people to teach, learn from and learn about other people, places and times	20	30
4.2 Relating to others	The arts allow people to relate to and/or empathise with other people and experiences	24	21

I am making things for others to receive, and I know that they will be appreciated. [Phase 1, any form of crafts].

I ... sell my art online and feel connected to the people who buy regularly from me. [Phase 2, done painting, drawing, printmaking, sculpture, etc.]

The act of sharing, then, was seen as connecting for people engaging in the arts together but also for people who share their art with others who may not necessarily be present.

*Theme 3. Facilitating commonality and belonging*

At both phases, the arts were reported as eliciting feelings of proximity with others (subtheme 3.1), regardless of whether the activity itself was being shared directly with someone else:

[I] have viewed various museums e.g., Vatican City and Natural History Museum, London, online and because there were other people there, it felt as though I was not alone in viewing the exhibits. [Phase 1, attended an exhibition, museum, or collection of art, photography, sculpture or any other arts].

I know there are other people out there doing this alone too and it makes me feel less alone, and the people showcasing the dance motivates me to do something and feel like I am there with them. [Phase 2, practised, rehearsed or performed dance].

Importantly, this feeling of proximity was often 'virtual'; a feeling of being near other people through online or digital interaction. Subtheme 3.2 expands the idea of commonality and belonging, focusing on how the arts connected people to others with common interests:

It is some meaningful effort to join the online live gig at the right time, so those who attend have a genuine shared interest. [Phase 1, attended live music].

Feels good to be with others enjoying the same thing and connected via the pandemic. [Phase 2, attended live theatre or circus].

Linked with this, for a smaller group of respondents, the arts allowed people to feel part of, and belonging to, something bigger than themselves (subtheme 3.3):

Staying indoors as much as possible has significantly reduced human interaction. Music is helping to replicate the feeling of belonging. [Phase 1, listened to recorded music].

If you watch films together you have something to discuss and feel that you have a “community” experience. [Phase 2, Watched a film or drama].

As these examples illustrate, the arts replicated the feeling of belonging during COVID-19 that other research has observed pre-pandemic.<sup>16–20</sup> Interestingly, the arts also supported people to feel part of a collective ‘COVID experience’ (sub-subtheme 3.3.1):

I listen to podcasts that are frequently mentioning the Coronavirus and how it is affecting them and how they are dealing with all issues related to it, including self-isolation. I feel like I can empathise and relate to the people on the podcast as I am in a similar situation. [Phase 1, listened to audio books or podcasts].

It connects me with other people, and it doesn't make me feel the distance between us as much as we all go through this common experience. [Phase 2, attended live music].

Closely linked, the arts were reported as providing a collective distraction from the pandemic (sub-subtheme 3.3.2):

The radio has been good company and a distraction from the current situation, bringing some normality ... The camaraderie of the presenters has made me feel part of a larger family. [Phase 1, listened to recorded music].

It's nice to compare books with others and escape to a world without COVID. [Phase 2, read as a pastime activity].

These sub-subthemes were new to this data set and demonstrate COVID-specific ways that the arts appeared to contribute to collective ways of coping during the pandemic.

#### *Theme 4. Facilitating collective understanding*

Theme 4 captured how the arts can facilitate collective understanding. Here, there was evidence that respondents used the arts to teach, learn from and learn about other people during the pandemic (subtheme 4.1):

[I] have made things and discussed design of them with my family. My wife and daughter make stained glass ornaments and they have taught me. [Phase 1, any form of crafts].

I have practised some songs on my guitar then helped other people learn them. [Phase 2, played a musical instrument or sang].

Alongside, respondents reported that the arts allowed them to relate to and/or empathise with other people (subtheme 4.2):

I've been playing music during the Thursday 8pm “noise for key workers” and have seen and related to many neighbours. [Phase 1, played a musical instrument or sang].

[Attending] allows me to share and understand people's perceptions of a subject matter. [Phase 2, attended an event connected with books or reading].

Of note is that Theme 4 had substantially fewer instances than the other themes.

## **Discussion and conclusion**

Arts and cultural engagement supported feelings of social connectedness over two phases in the first year of the pandemic through four pathways: facilitating social opportunities, facilitating sharing, facilitating commonality and belonging and facilitating collective understanding. These pathways replicate prepandemic findings<sup>8</sup> and, while there were some small differences in subtheme instances, hold consistent for both phases of data collection, indicating sustainability and durability in the role of the arts to support social connections, including during times of crisis. This adds to a growing body of literature that points to the role of the arts in supporting social public health.<sup>9,10,21–26</sup> The subthemes shed light on specific ways that respondents used the arts during the pandemic to connect with others; both within the household if applicable but also outside of the household via phone or technology. These included using the arts: as a catalyst for conversations, to maintain, reinstate or strengthen relationships during social distancing and to facilitate social interactions (Theme 1); to bring people together through shared experiences and sharing of art (Theme 2); to elicit feelings of direct and indirect proximity to others, to connect people with common interests, to feel a sense of belonging to something and to feel part of a collective ‘COVID-19 experience’ or to feel collectively distracted from the pandemic (Theme 3); to learn from and about other people and to relate to others (Theme 4). These findings complement other research suggesting that participating in creative activities during COVID-19 could be linked with reduced loneliness<sup>27</sup> and that people coped with loneliness during the pandemic through, among other things, creative arts and writings.<sup>28</sup>

The arts and cultural activities most frequently cited as connecting, across both phases, were watching a film or drama and listening to recorded music. Interestingly, these activities are linked to those identified as most connecting prepandemic: attending a live music performance, watching a live theatre performance and watching a film or drama at the cinema or other venue.<sup>8</sup> It seems that the activities were adapted to the pandemic; for example, films and dramas were likely watched at home rather than at a cinema – online streaming services had a rapid rise in viewers<sup>29</sup> – and music was seemingly accessed through listening to recordings. Implied here is that people adapted their arts and cultural engagement to fit pandemic-related restrictions either to enable a continuation of prepandemic means of connection or to find new ways of connection in a time of social distancing.

The strengths of this article include the large qualitative sample, allowing for the representation of respondents with a range of sociodemographic characteristics. The longitudinal design captured perceptions at two different points during 2020, avoiding only one snapshot in a rapidly changing social context and demonstrating consistency in the findings. Furthermore, we included multiple subthemes to capture the nuanced and subtly different ways in which the arts were perceived to facilitate connections. Many responses were complex and therefore coded to multiple subthemes, indicating a degree of inherent overlap that we have retained to indicate the multifaceted and interlinking nature of the responses.



The limitations include an explicit focus on arts and culture, meaning that we are not able to conclude whether arts and culture support feelings of connectedness *more* than other activities. Indeed, our data are not intended to reveal any causal link between arts and cultural engagement and social connectedness. Finally, of our initial sample of 3647, a substantial 1291 reported not engaging in the arts, and a further 603 reported that the arts did not connect them to others. Therefore, our findings should be interpreted with caution, as they represent only those who *do* engage with the arts and who *do* report it to support their social connections.

Given the potential for arts and cultural activities to support social connectedness, the issue of *who* accessed the arts – during the pandemic and beyond – becomes important. Predictors of increased arts engagement during the first months of COVID-19 in the United Kingdom included younger people (aged 18–29 years), people who had lost work, those who were not keyworkers, people with greater social support and those who worried about catching COVID-19.<sup>11</sup> We know there is a ‘social gradient’ in arts and cultural engagement<sup>30,31</sup> and that barriers include poorer health, lower socioeconomic status, loneliness and living alone.<sup>32</sup> The data reported here suggest that engagement with arts and culture has continued to support social connectedness during the pandemic, providing further evidence for the importance of future research and policy designed to inform equal access to the arts, particularly for those at risk of or experiencing loneliness.

## Author statements

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## Competing interests

None declared.

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Original Research

# No increased incidence of venous thrombosis or pulmonary embolism after SARS-CoV-2 vaccination in Germany

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## ABSTRACT

**Objectives:** Vaccination is one of the most effective measures to combat the COVID-19 pandemic. The main reason for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) vaccination hesitancy is the potential side-effects. This study aimed to investigate the incidence of venous thrombosis and pulmonary embolism in patients who received SARS-CoV-2 vaccination.

**Study design:** This was a retrospective cohort study.

**Methods:** Individuals aged  $\geq 18$  years who received an initial vaccination for COVID-19 in one of 1134 general practices in Germany between April and June 2021 were included in the study. Vaccinated patients were matched to unvaccinated individuals by age, sex, index month (April to June 2020 [unvaccinated cohort] or April to June 2021 [vaccinated cohort]) and diagnoses that may be associated with an increased incidence of thrombosis documented within 12 months before the index date. The incidences of thrombosis and non-fatal pulmonary embolism as a function of COVID-19 vaccination were analysed.

**Results:** The present study included 326,833 individuals who were vaccinated against COVID-19 and 326,833 matched unvaccinated individuals. During the follow-up period, 406 vaccinated patients and 342 individuals in the control group received a diagnosis of thrombosis or non-fatal pulmonary embolism. This resulted in an incidence rate of 11.9 vs 11.3 cases per 1000 patient-years for vaccinated vs unvaccinated individuals, respectively, and a non-significant overall incidence rate ratio (IRR: 1.06; 95% confidence interval [CI]: 0.93–1.22). The highest IRR was observed in the 41–60 years age group (IRR: 1.30; 95% CI: 0.98–1.73), and the lowest IRR was seen in the 18–40 years age group (IRR: 0.6; 95% CI: 0.0–1.05); however, none of the individual age group incidence rates was significant.

**Conclusions:** The results indicate that the occurrence of thrombosis or pulmonary embolism after COVID-19 vaccination is a coincidental finding rather than a consequence of vaccination.

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## Introduction

The COVID-19 pandemic has had a dramatic impact worldwide, affecting both social lives and economic development.<sup>1–5</sup> The use of the recently developed vaccines has proven effective in combating the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and preventing severe outcomes of COVID-19.<sup>6</sup> However, vaccine hesitancy has been reported in many countries for a variety of reasons.<sup>7</sup> Although vaccine rollouts have increased

over time, vaccination hesitancy has remained an issue.<sup>7,8</sup> In addition to an obvious gap in vaccination rates between developed and developing countries, a similar trend has emerged regarding vaccine hesitancy, with factors such as higher education level, higher income, non-rural residency and free vaccination provision being identified as determinants for vaccine acceptance.<sup>7,8</sup> Some investigations have indicated that a general trust in authorities and the government correlates strongly with willingness to be vaccinated.<sup>7</sup> However, potential vaccine side-effects have been identified as the most common reason for COVID-19 vaccine hesitancy and were cited by more than 90% of the vaccine-hesitant individuals questioned.<sup>8,9</sup> Common postvaccination side-effects, such as local reactions, fever, fatigue, headache or joint pain, are of minor relevance and are non-life threatening.<sup>10</sup> On the other hand, some

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events, such as autoimmune inflammatory neurological or vascular and haematological disorders, including myocardial infarction, thrombosis, cerebral vein thrombosis and thrombocytopenia, have been identified as having a potential association with the vaccine (11–15). However, reports of these types of serious adverse events in the literature are rare, and their link to COVID-19 vaccination remains a topic of discussion.<sup>16</sup> In the context of vaccine hesitancy and the global COVID-19 pandemic, it is important to investigate the incidence of such events using robust data, for example, data derived from large-scale investigations. Providing reliable evidence of the safety of COVID-19 vaccines may help to boost confidence and improve acceptance of these recently developed vaccines.

Therefore, this study investigated the frequency of thrombosis and non-fatal pulmonary embolism in patients who received the SARS-CoV-2 vaccine. Data were obtained from a large database that is supplied with information from general practitioners (GPs) and specialists in Germany.

## Methods

### Database

This study used data from the Disease Analyzer database (IQVIA), which contains drug prescriptions, diagnoses and basic medical and demographic information that is obtained directly and in an anonymous format from computer systems used in the practices of GPs and specialists.<sup>17</sup> The database covers approximately 3% of all outpatient practices in Germany. Diagnoses (according to International Classification of Diseases, 10th revision [ICD-10]), prescriptions (according to Anatomical Therapeutic Chemical classification system) and the quality of the reported data are monitored regularly by IQVIA. In Germany, the sampling methods used to select physicians' practices are appropriate for obtaining a representative database of general and specialised practices. It has previously been shown that the panel of practices included in the Disease Analyzer database is representative of general and specialised practices in Germany.<sup>17</sup> In addition, this database has already been used in previous studies focusing on COVID-19<sup>18,19</sup> as well as cardiovascular outcomes.<sup>20,21</sup>

### Study population

This retrospective cohort study included individuals aged  $\geq 18$  years who received a COVID-19 vaccination in one of 1134 general practices in Germany between April and June 2021 (index date; Fig. 1). Individuals with thrombosis (ICD-10: I80–I82) or pulmonary embolism (ICD-10: I26) diagnoses within the 12 months before the index date were excluded, as were those diagnosed with COVID-19 either before the index date or during the follow-up period.

Vaccinated patients were matched to unvaccinated individuals on the basis of greedy nearest-neighbour propensity scores derived from the logistic regression analysis using age, sex, index month (April, May, and June), and diagnoses that may be associated with an increased incidence of thrombosis documented within 12 months before the index date, including obesity (CD-10: E66), atrial fibrillation (ICD-10: I48.0, I48.1, I48.2, I48.9), heart failure (ICD-10: I50), ischaemic heart diseases (ICD-10: I20–I25), cancer (ICD-10: C00–C97), coagulation defects (ICD-10: D65–D69), varicose (ICD-10: I83–I85), injuries (ICD-10: S00–T12, within 6 months) and status postsurgery (ICD-10: Z98, within 6 months). As only vaccination information from GPs and not from vaccination centres was available, unvaccinated individuals (the matched cohort) were selected based on a randomly selected visit date between April and June 2020 because no COVID-19 vaccinations were available during this period (Fig. 1).

### Study outcomes and statistical analyses

The main outcome of the study was the incidence of thrombosis (ICD-10: I80–I82) and non-fatal pulmonary embolism (ICD-10: I26) diagnoses as a function of COVID-19 vaccination. Each individual was followed up for a maximum of 122 days after the index date. Differences in the sample characteristics between vaccinated and unvaccinated individuals were analysed using McNemar tests for categorical variables and paired sample Wilcoxon tests for continuous variables. Poisson regression models were used to obtain incidence rate ratios (IRRs), taking account of differential exposure times via offsets. Marginal models were estimated using the generalised estimation equations method to account for the correlation of observations within matched pairs. *P* values  $< 0.05$  were considered statistically significant. Analyses were carried out using SAS version 9.4 (SAS Institute, Cary, USA).

## Results

### Basic characteristics of the study sample

The present study included 326,833 individuals who received a COVID-19 vaccination between April and June 2021, and 326,833 individuals with a GP visit between April and June 2020. The basic characteristics of the study participants are shown in Table 1. The mean age of participants was 55.7 (standard deviation [SD] 17.3) years; 49.3% were women in both groups. On average, vaccinated individuals were followed up for 38 days and unvaccinated individuals for 34 days after the index date.

### Association between COVID-19 vaccination and thrombosis or non-fatal pulmonary embolism

During the follow-up period, 406 vaccinated patients and 342 unvaccinated patients were diagnosed with thrombosis or non-fatal pulmonary embolism. This resulted in an incidence rate of 11.9 vs 11.3 cases per 1000 patient-years for vaccinated vs unvaccinated individuals, respectively, and a non-significant IRR of 1.06 (95% confidence interval [CI]: 0.93–1.22; see Table 2). The highest IRR was observed in the 41–60 years age group (IRR: 1.30; 95% CI: 0.98–1.73), and the lowest IRR was seen in the 18–40 years age group (IRR: 0.6; 95% CI: 0.0–1.05); however, none of the individual age group incident rates was significant.

## Discussion

Using a large-scale database, this study found no significant difference in the incidence rates of thrombosis or non-fatal pulmonary embolism between individuals who had received the COVID-19 vaccine and matched unvaccinated individuals. In the subgroup of vaccinated individuals aged 41–60 years, the incidence rate of 12.0 cases per 1000 patient-years for thrombosis or non-fatal pulmonary embolism exceeded the value calculated for unvaccinated patients, resulting in an IRR of 1.30. Although this result is non-significant, it must be acknowledged and verified in further investigations. No relevant differences were noted in the other age groups, and no sex-specific trends were detected.

Pivotal trials for SARS-CoV-2 vaccines clearly demonstrate that the vaccines offer great efficacy in preventing severe outcomes of COVID-19.<sup>22–25</sup> In terms of safety, very few severe adverse events related to COVID-19 vaccination have been reported.<sup>22–25</sup> Of the few severe events reported, the most noteworthy are several cases of peripheral facial nerve palsy, one case of transverse myelitis tinnitus, and a number of cases of tinnitus.<sup>22–25</sup> Reports of these uncommon and unexpected severe adverse events remain

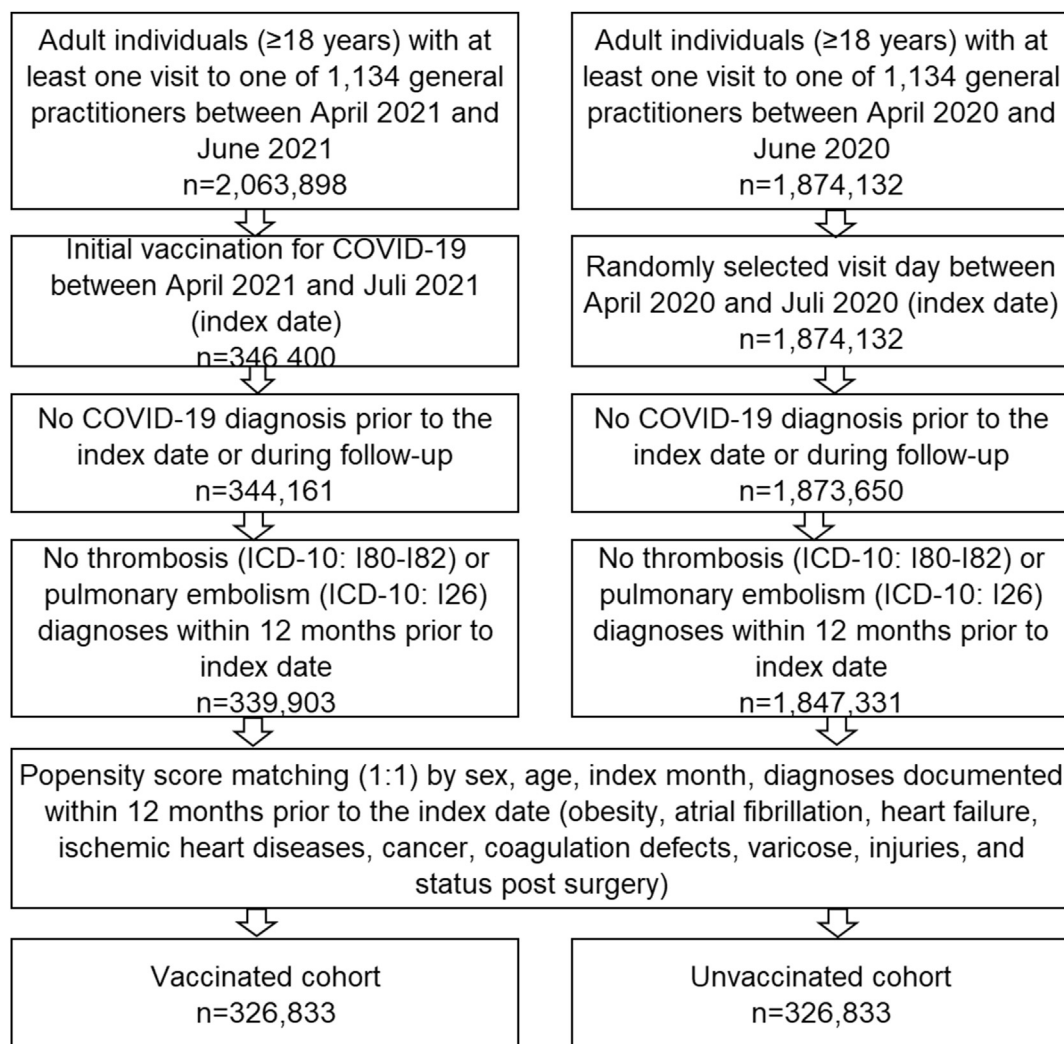


Fig. 1. Selection of study participants.

anecdotal and only involve approximately two dozen individuals across all trials; however, the authors have critically discussed their potential association with the vaccine.<sup>22–25</sup> Among 19,630 individuals receiving a single dose of the Ad26.COV2.S vaccine (Janssen vaccine), 15 cases of thromboembolic events were reported.<sup>24</sup> This number matched rates seen in the placebo group (n = 10), rendering a causative relationship to the vaccination unlikely.<sup>24</sup> However, cases of thrombotic and embolic events were increasingly reported with growing vaccination rates worldwide.<sup>11–15</sup> In November 2021, Bilotta et al. described 58 cases of haemostatic complications after COVID-19 vaccination, demonstrating that both the arterial and venous systems can be affected and identifying cerebral vein thrombosis as the most common event.<sup>12</sup> In a recently published (December 2021) systematic review including 98 studies, Al-Ali et al. described 460 thrombotic events as a potential post-COVID-19 vaccination complication, reporting 159 (34.6%) cases of cerebral vein thrombosis, followed by 67 venous thromboses (14.6%) and 63 cases (13.7%) of pulmonary embolism.<sup>11</sup> Thrombocytopenia was frequently observed in patients with postvaccination thrombotic events, indicating that this phenomenon may be related to the still unclear pathological mechanism behind this adverse reaction.<sup>11–15</sup> However, the data presented on thrombotic and thromboembolic events after COVID-19 vaccination, such as thromboses or pulmonary embolism, are

limited to anecdotal reports or case series. There is currently a lack of data on incidence rates for these events in vaccinated individuals compared with unvaccinated individuals to enable risk estimation.

Vein thrombosis and pulmonary embolism occur frequently in patients with predisposing risk factors. Furthermore, the intake of haemostasis-modulating drugs influences the occurrence of these events.<sup>25,26</sup> The overall crude incidence rate of thrombotic and thromboembolic events in total population is far lower, at around one in 1,000 per year, compared to people with risk factors.<sup>27</sup> The present study participants (vaccinated and matched unvaccinated individuals) may have a low to medium risk of thrombotic and thromboembolic events due to selection bias when prioritising ill or vulnerable individuals for vaccination. However, we detected the same incidence rate in both the vaccinated and unvaccinated groups, which is a major finding of the present study. The incidences of thrombotic and thromboembolic events in the vaccination group detected in the present study represent the expected intrinsic rate in a low- to medium-risk population rather than a result of COVID-19 vaccination. However, although the results of the present study clearly indicate that vaccination against COVID-19 is not a factor for facilitating thrombotic and thromboembolic events, these findings require verification in further large-scale investigations.

**Table 1**  
Basic characteristics of the study participants after 1:1 matching.

Variable	Vaccinated individuals (%) (n = 326,833)	Unvaccinated individuals (%) (n = 326,833)	P-value
Age (mean, SD)	55.7 (17.3)	55.7 (17.3)	0.886
<b>Age group</b>			
18–40 years	20.9	20.9	0.992
41–60 years	35.3	35.3	
61–70 years	24.1	24.1	
>70 years	19.7	19.7	
<b>Sex</b>			
Female	49.3	49.3	1.000
Male	50.7	50.7	
<b>Index month</b>			
April	32.5	32.5	1.000
May	39.5	39.5	
June	28.0	28.0	
<b>Diagnoses in previous 12 months</b>			
Obesity	12.4	12.4	1.000
Atrial fibrillation	4.3	4.3	1.000
Heart failure	4.4	4.4	1.000
Ischaemic heart diseases	9.2	9.2	1.000
Cancer	6.7	6.7	1.000
Coagulation defects	1.0	1.0	1.000
Varicose	5.4	5.4	1.000
Injuries (within last 6 months)	4.0	4.0	1.000
Surgery (within last 6 months)	0.4	0.4	1.000

SD, standard deviation.

Proportions of patients are given in percentage unless otherwise indicated.

**Table 2**  
Association between COVID-19 vaccinations and the incidence of thrombosis or non-fatal pulmonary embolism in patients followed up in general practices in Germany (Poisson regression models).

Variable	Cases per 1000 patient-years among vaccinated individuals	Cases per 1000 patient-years among unvaccinated individuals	IRR (95% CI)	P-value
Total	11.9	11.3	1.06 (0.93–1.22)	0.457
<b>Age group</b>				
18–40 years	4.2	7.4	0.56 (0.30–1.05)	0.072
41–60 years	12.0	9.2	1.30 (0.98–1.73)	0.067
61–70 years	11.6	11.3	1.03 (0.78–1.35)	0.828
>70 years	14.9	14.5	1.03 (0.82–1.29)	0.784
<b>Sex</b>				
Female	12.6	12.5	1.02 (0.84–1.23)	0.879
Male	11.1	10.0	1.12 (0.90–1.38)	0.339

CI, confidence interval; IRR, incident rate ratio.

The two major strengths of this study are the number of patients available for analysis and the detailed analyses performed using real-world data. This study is also subject to several limitations that should be acknowledged. First, the thrombosis and pulmonary embolism diagnosis data relied solely on ICD-10 codes, and no data were available on the diagnosis process or the severity/activity of the disease. Second, as no information was available on behavioural factors (e.g. alcohol use, smoking, use of contraceptive drugs and sedentary lifestyle), the roles played by these factors could not be examined. Third, no hospital data were available, and only out-patients were analysed; severe cases of both COVID-19 and thrombosis are treated in hospitals. Fourth, analyses were not stratified by vaccination manufacturer; however, >90% of patients in this study received the BNT162b2 vaccine, a COVID-19 messenger RNA vaccine. Fifth, injuries as a risk factor for thromboses was not included in the match-pairs variables because of the very small number of individuals with documented injuries during the study period. Finally, the database does not contain data on mortality; thus, no fatal events could be analysed.

### Conclusions

In this large-scale investigation examining the incidences of thrombosis and pulmonary embolism, no differences were detected

between COVID-19-vaccinated and unvaccinated individuals. It is therefore very likely that when these conditions occur after SARS-CoV-2 vaccination, they are an inevitable part of the medical history of the individual rather than a consequence of vaccination.

### Author statements

#### Ethical approval

The database used in this study includes only anonymised data in compliance with the regulations of the applicable data protection laws. German law allows the use of anonymous electronic medical records for research purposes under certain conditions. According to this legislation, it is not necessary to obtain informed consent from patients or approval from a medical ethics committee for this type of observational study that contains no directly identifiable data. As patients were only queried as aggregates and no protected health information was available for queries, no institutional review board approval was required for the use of this database or the completion of this study.

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### Competing interests

All authors hereby declare that they have no conflicts of interest or competing interests related to the current article.

### Author contributions

KK and CT developed the idea for the study, KK and RZ analyzed the data. CT, JR and KK wrote the manuscript. All authors contributed to and reviewed the final version of the manuscript.

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Letter to the Editor

## Precarious migrants and COVID-19 responses: leave no one behind



The continuous rise in forced displacement worldwide is alarming. Global inequality continues to fuel migration. The most recent Global Trends report by United Nations High Commissioner for Refugees reveals a concerning rise in forced displacement globally, with 82.4 million people displaced worldwide, with children representing 42%, with 1 million born in displacement between 2018 and 2020.<sup>1</sup> According to the United Nations Migration Agency's (IOM) World Migration Report 2022, global displacement is rising despite COVID-19 restrictions.<sup>2</sup>

Estimating the numbers of precarious migrants is difficult. The population is de facto hidden. In Europe, it is estimated that between 3.9 and 4.8 million precarious migrants lived in Europe in 2017, an increase on 2014, but stable since 2016.<sup>3</sup> In the United Kingdom, the estimated population of precarious migrants ranges between 417,000 and 863,000, including a population of UK-born children ranging between 44,000 and 144,000.<sup>4</sup>

The COVID-19 syndemic,<sup>5</sup> which began in early 2020, has posed a myriad of challenges all over the globe. COVID-19 has disrupted mobility, socio-economic opportunities and the public health of the displaced, including those who have precarious migration status, and has substantially exacerbated health vulnerabilities.<sup>6</sup> Regarding precarious migrants, very little is known about their experience of government restrictions and disaster measures, nor of their ability to navigate public health guidance and protect oneself from disease. The level of social and health vulnerability faced by them is disproportionately higher than those who have access to the basic rights associated with recognised citizenship of a nation state. In the United Kingdom, for example, most stateless people are precarious migrants and can be viewed as being at significant risk of human rights violations as a result of their immigration status. A recent European situation assessment on statelessness, health and COVID-19 has revealed a series of health right violations, health inequalities and chronic ill health of immigrants, including those affected by statelessness, who often live in congested and substandard unhygienic conditions, work in informal sectors, which hampers their adherence to public health measures (self-isolation/physical distancing/hand sanitation), or who are detained in immigration detention centres.<sup>7</sup> The interplay between poor environmental determinants of health, inability to access to healthcare services (including testing and vaccination) and racism and vilification are evident during COVID-19 state disaster measures.

Whilst the right to health care is a fundamental human right, with universal application and with access to healthcare services ensured to every human being without regards to race, religion or other criteria, including nationality status, this is not the case for precarious migrant communities during the COVID-19 public health and state emergency. The right to a nationality (and

realisation of the right to health and access to healthcare/public services) is now even more crucial than before and warrants an inclusive, targeted effective and culturally sensitive public health community-driven response. We cannot underestimate the need for sensitive legal, health and social response measures to tackle disease transmission in vulnerable groups, hate crime, racism, xenophobia and discrimination of those perceived to be at risk of contagion.

There is an imperative to understand the experiences and medico-legal situation of precarious migrants to generate evidence-based measures, responses and actions to protect health and those most at risk. Their hidden nature within our countries and our communities coupled with substantial health marginalisation is exacerbated by government migration policy. Early-stage participatory action research during the COVID-19 period with precarious migrants in the United Kingdom has captured such dimensions<sup>8</sup> and has revealed both resilience and systemic barriers to fostering that resilience.

Enabling precarious migrants who suffer substantial health and social vulnerability to protect themselves and those around them from disease, alongside everyone else in the society should be prioritised not only in the United Kingdom, but globally.

Leave no one behind.

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## Original Research

## SARS-CoV-2 seroprevalence and determinants of infection in young adults: a population-based seroepidemiological study

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## ABSTRACT

**Objectives:** Most SARS-CoV-2 seroprevalence studies have focussed on adults and high-risk populations, and little is known about young adults. The objective of the present study was to provide evidence on the SARS-CoV-2 seroprevalence among young adults in Germany and to explore determinants associated with seropositivity in general and, specifically, with previously undetected infections.

**Study design:** This was a population-based SARS-CoV-2 seroprevalence study.

**Methods:** In November 2020, a population-based study on SARS-CoV-2 seroprevalence in young adults (aged 18–30 years) was conducted in a large German city. Serum samples were obtained to analyse the SARS-CoV-2 antibody status using the Elecsys Anti-SARS-CoV-2 immunoassay. Descriptive statistics and odds ratios (ORs) of seropositivity and of previously undetected infections in relation to different determinants were calculated.

**Results:** Among 2186 participants, SARS-CoV-2 antibodies were detected in 72 individuals, equalling a test performance-adjusted seroprevalence of 3.1% (95% confidence interval [CI]: 2.4–4.0). Based on reported COVID-19 cases to the public health authority, a moderate underascertainment rate of 1.7 was calculated. Seropositivity was higher among individuals who sought COVID-19-related information from social media (OR: 1.83, 95% CI: 1.2–3.1), and undetected COVID-19 infections were more prevalent among men and those not adhering to social distancing.

**Conclusions:** The results show a substantial underascertainment of SARS-CoV-2 infections among young adults and indicate that seroprevalence is likely to be much higher than the reported COVID-19 prevalence based on confirmed COVID-19 cases in Germany. Preventive efforts should consider the heterogeneity of risk profiles among the young adult population.

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## Introduction

In Germany, the new coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2), first appeared in January 2020. At the beginning of the pandemic, high incidence rates were primarily reported among the elderly population; however, the age distribution of those infected with COVID-19 began to shift when numbers started to

increase significantly among the younger population in late summer 2020.<sup>1–3</sup> Since the start of the pandemic, there have been ongoing debates about COVID-19 susceptibility in young adults; however, empirical evidence remains scarce and often inconclusive.<sup>4–6</sup>

In this context, the use of seroprevalence studies, which assess the number of people in a population who test positive for a specific disease based on blood serum, can help to determine the number of infections at the population level and to identify the magnitude of undetected cases. Currently, however, most SARS-CoV-2 seroprevalence studies have focussed on the general population or on specific high-risk groups (e.g. hospital staff),<sup>7,8</sup> and only a few studies have considered young adults.<sup>4</sup> In some studies, the sample size was too small to enable age group-specific evaluations, and in

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the larger studies, young adults were frequently not considered as a separate group.<sup>9–11</sup> In studies that did evaluate young adults, only descriptive analyses were conducted;<sup>8,12</sup> for example, findings from Europe determined the seroprevalence for individual age groups and found that it was highest among 20- to 34-year-olds.<sup>8,12</sup> To the best of our knowledge, to date, more in-depth studies among young adults have not been carried out.

Many previous studies were conducted during the first pandemic wave, at a time when the COVID-19 incidence was relatively low among young people. From a public health perspective, data on SARS-CoV-2 seroprevalence among young adults are of great importance for several reasons, including (1) young adults are characterised by a high number of asymptomatic cases, which may contribute to the undetected transmissions of the disease;<sup>13</sup> (2) young adults are characterised by distinct determinants, including low-risk perception and high mobility;<sup>13,14</sup> and (3) although most young adults experience a mild disease course, there are increasing concerns of long-term adverse health effects<sup>15</sup> and identifying factors linked to infection risk (both detected and undetected) can help to understand SARS-CoV-2 transmission dynamics and consequently support the development of targeted prevention measures. The present study aims to provide evidence on SARS-CoV-2 seroprevalence among young adults in Germany in November 2020 (i.e. during the second pandemic wave in Germany) and to explore determinants associated with seropositivity in general and, specifically, with previously undetected infections.

## Methods

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for reporting cross-sectional studies was followed in the present study.<sup>16</sup>

### Study design, population and sampling

SERODUS is a population-based, cross-sectional seroepidemiological study, which was conducted in Düsseldorf (Germany) between 2 and 27 November 2020. The sampling frame consisted of all individuals aged 18–30 years who were registered in Düsseldorf in October 2020 ( $n = 106,449$ ). The study sample was selected via random sampling through the population registry (Fig. 1). The minimum sample size was calculated to be 1600–2000 individuals, with 95% confidence limits and assuming an anticipated seroprevalence of 1–6% or lower. The anticipated seroprevalence of 1–6% was chosen based on earlier reports that suggested a SARS-CoV-2 seroprevalence of between 1% and 6% in the general adult population.<sup>17–19</sup> To estimate even simple group differences with acceptable error intervals, the target corridor was a net sample of  $2000 \pm 400$  individuals. Inclusion criteria were (1) permanent residence in Düsseldorf, (2) aged 18–30 years at that date when the serum sample was taken and (3) providing written informed consent. All potential participants were invited through written personal postal invitation letters (step 1) sent to their private mailboxes, including information about the study, a personal invitation number and a link to the study website. If interested in participation, an appointment could be made via the study hotline. Given the short recruitment phase of 14 days, reminder letters were sent out 5 days after the initial invitation (step 2).

### Informed consent

Participants provided written and informed consent.

## Measures

The primary study outcome was SARS-CoV-2 seroprevalence, and the secondary outcome was determinants associated with seropositivity. After providing written and informed consent, study participants completed a self-administered questionnaire, and a blood sample was taken.

Established survey instruments were used to obtain information on participants' sociodemographics (e.g. age and educational level), COVID-19-related symptoms (e.g. fever), chronic conditions (e.g. diabetes), exposure (e.g. participation in festivities) and behaviour-related factors (e.g. adherence to COVID-19 public health measures). Questions relating to sociodemographic characteristics were taken from the demographic standards defined by the German federal statistics office.<sup>20</sup> Questions concerning adherence to and support of COVID-19-related public health measures were taken from a COVID-19 questionnaire provided by the Robert Koch Institute, Germany's central public health authority.<sup>21</sup> General adherence to public health measures was assessed by asking respondents, "To what extent do you adhere to the coronavirus containment measures, which came into effect on March 18, 2020?" Specific public health measures investigated included social distancing (in private and public settings) and wearing a face mask in public. The type and frequency of the source used to retrieve COVID-19-related information were investigated by asking respondents, "How often do you use social media for COVID-19-related information?" All study material was provided in German, English, Turkish and Arabic languages.

### Laboratory analysis and assays

Serum samples were tested for antibodies (including IgG, IgA and IgM) against the nucleocapsid antigen of SARS-CoV-2 (N) using the Elecsys Anti-SARS-CoV-2 immunoassay (Roche Diagnostics, Mannheim, Germany). The assay was performed on a Cobas e801 analyser (Roche Diagnostics, Mannheim, Germany) according to the manufacturer's instructions. The results showing a cut-off index (COI) of  $<1.0$  were classified as negative, and a COI  $\geq 1.0$  was deemed positive for anti-SARS-CoV-2 antibodies (hereinafter referred to as seropositive). According to internal study data of Roche Diagnostics, the overall clinical specificity of the Elecsys Anti-SARS-CoV-2 immunoassay was 99.8% containing no cross-reactivity to the common cold coronaviruses, and additionally, a clinical sensitivity of 99.5% was calculated  $\geq 14$  days post polymerase chain reaction (PCR) confirmation. Serum samples with positive results were subject to SARS-CoV-2 neutralisation assay to detect SARS-CoV-2 neutralising antibodies with a titre of  $\geq 1:10$  being considered positive.<sup>22</sup>

### Data analysis

Data analysis followed a three-step approach.

First, descriptive statistics, including the calculation of frequencies and percentages, were performed to describe the sample and the seroprevalence among young adults.

Second, the underascertainment rate of SARS-CoV-2 infections was calculated. This was based on the ratio of two population proportions: the proportion of SARS-CoV-2 infections calculated from our study and the cumulative incidence of non-fatal PCR-positive cases in the young adult population of Düsseldorf. These estimates were adjusted for test sensitivity (99.5%) and specificity (99.8%) of the Roche Cobas Elecsys Anti-SARS-CoV-2 test.<sup>23</sup>

Third, to investigate the association between seropositivity and possible risk factors, a series of logistic regressions to calculate odds ratios (ORs) were performed. Specifically, the OR for seropositivity was estimated separately for each main exposure of interest (e.g.

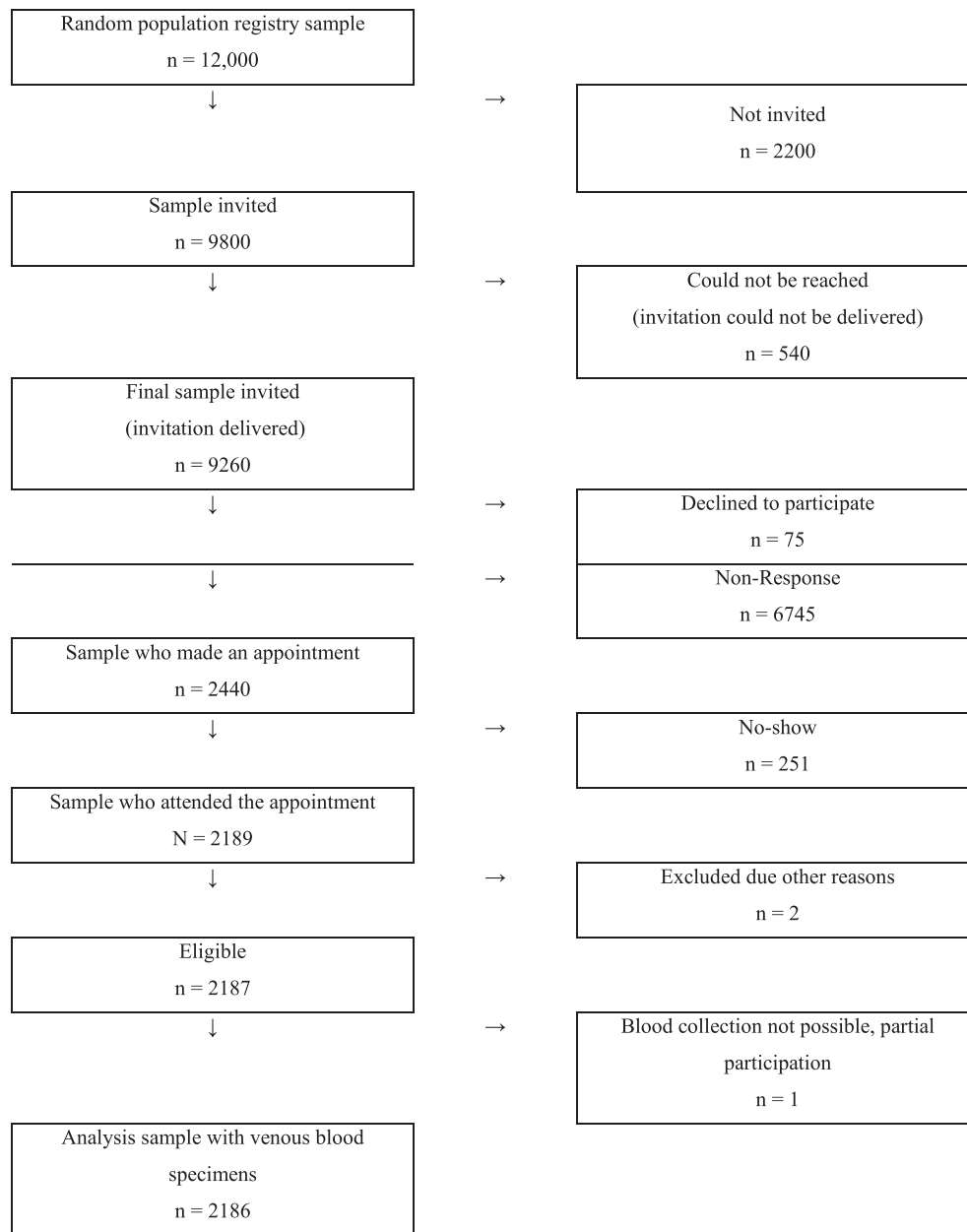


Fig. 1. Flow diagram of participant recruitment, enrolment, and study completion.

adherence to public health measures, travelling outside the European Union [EU] etc.; Model 1). In Model 2, each estimate was adjusted for age and sex (the estimate for age is adjusted only for sex, and the estimate for sex is adjusted only for age).

Analyses were performed using Stata version 15 (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC). All statistical models fit the data well according to the Hosmer–Lemeshow goodness-of-fit test (see [supplementary material Table S1](#)).

## Results

A total of 2189 individuals attended the study centre (Fig. 1). Three observations were excluded because the individuals could not be tested (e.g. syncope). This yielded an analytic sample of 2186 individuals (24% of those invited) with complete records (i.e. informed consent, questionnaire and laboratory results; Fig. 1).

### Sample characteristics

Table 1 shows the sociodemographic characteristics, and Table 2 shows the health- and behaviour-related characteristics of the study participants. Of 2186 participants, 60.7% were female, 37.2% were aged 20–25 years, and 16.9% had a migration background (Table 1). Most participants rated their health as good (81%) and chronic conditions were rare, with only 9.2% of participants reporting having one or more chronic conditions (Table 2).

### Seroprevalence

Of 2186 young adults who participated in the present study, a total of 72 individuals were seropositive, representing a crude prevalence rate of 3.3% (95% confidence interval [CI]: 2.6–4.1) and a test-adjusted prevalence of 3.1% (95% CI: 2.4–4.0; Table 3). The



**Table 1**  
Sociodemographic characteristics of study participants (n = 2186).

Characteristics	Participants, n (%)
Sex	
Female	1327 (60.7)
Male	857 (39.2)
Missing	2 (0.1)
Age group	
<20 years	139 (6.4)
20–25 years	813 (37.2)
26–30 years	1218 (55.7)
Missing	16 (0.7)
Household size	
1 person	575 (26.3)
2 persons	1027 (47.0)
≥3 persons	567 (25.9)
Missing	17 (0.8)
Educational level <sup>a</sup>	
Lower and middle	171 (7.8)
Higher	1921 (87.9)
Still a student or other type of education	81 (3.7)
Missing	13 (0.6)
Employment status	
Not working <sup>b</sup>	110 (5.0)
Part-time and short-term (reduced working hours)	164 (7.5)
Full time	1180 (54.0)
Student	703 (32.2)
Missing	29 (1.3)
Migration background	
Yes	370 (16.9)
No	1803 (82.5)
Missing	13 (0.6)

<sup>a</sup> Participants' education level was assessed according to the 2011 version of the International Standard Classification of Education (ISCED) and grouped into low/middle education (e.g. primary education) and higher education.

<sup>b</sup> This also includes pensioners and parents on maternity leave.

cumulative incidence of reported cases in the population aged 18–30 years was 1.8% (as of November 2020). Based on the estimated test-adjusted seroprevalence of 3.1% and the cumulative incidence of 1.8%, it is estimated that approximately 1.7-fold more infections occurred than were ascertained by confirmed case counts. Only 31 (43.1%) of individuals with antibodies had tested positive for COVID-19 by PCR before the present study. Consequently, the within-study 'true' rate of unreported COVID-19 cases in this population is 2.3. Among the 72 seropositive individuals, neutralising antibodies were detected in 66 individuals (91.7%; Table 3).

### Determinants of a SARS-CoV-2 infection

Table 4 and Table S2 provide a detailed presentation of seroprevalence by sociodemographic and health-related characteristics. The proportion of men with positive SARS-CoV-2 antibodies (3.8%) was slightly higher than the proportion of women (2.7%). The odds of being seropositive was significantly higher among those with self-reported COVID-19 symptoms, such as loss of smell (OR: 55.6, 95% CI: 30.7–99.0), loss of taste (OR: 40.8, 95% CI: 23.0–75.5), fever ≥38 °C (OR: 5.06, 95% CI: 3.0–8.6), dyspnoea and shortness of breath (OR: 4.15, 95% CI: 2.1–7.6; Table S2). The odds of being seropositive were also almost two times higher for those who seek COVID-19-related information from social media (Table S2; OR: 1.83, 95% CI: 1.2–3.1). An increasing trend was seen in individuals who trust information from social media influencers (OR: 1.78, 95% CI: 0.9–3.3) and who do not support social distancing (Table S2; OR: 1.81, 95% CI: 0.9–3.7). Unexpectedly, we did not find evidence for a significant association between low self-reported general adherence to COVID-19 public health measures and seroprevalence (Table S2;

**Table 2**  
Health-related characteristics and social determinants of study participants (n = 2186).

Characteristics	Participants, n (%)
Self-reported health	
Very good/excellent	1771 (81.0)
Fair/bad	385 (17.6)
Missing	30 (1.4)
Chronic condition	
No	1975 (90.3)
Yes	201 (9.2)
Missing	10 (0.5)
PCR test since February 2020	
Yes	784 (35.9)
No, no test needed	1126 (51.5)
No, but I thought about getting tested	194 (8.9)
No, I asked for a test but did not get one	72 (3.3)
Missing	10 (0.5)
Self-reported COVID-19	
Yes	46 (2.1)
No	728 (33.3)
I do not know	10 (0.4)
Symptoms since February 1 <sup>a</sup>	
Fever ≥38 °C	225 (10.3)
Cough	648 (29.8)
Pneumonia	7 (0.3)
Dyspnoea/shortness of breath	121 (5.6)
Pain when breathing	112 (5.2)
Congested/running nose	848 (39.0)
Sore throat	854 (39.1)
Loss of smell or taste	100 (4.6)
No symptoms	511 (23.5)
Contact to a confirmed COVID-19 case	
No	1711 (78.3)
Yes, with a distance ≥1.5 m	179 (8.2)
Yes, with a distance <1.5 m	285 (13.0)
Missing	11 (0.5)
Other exposures <sup>a</sup>	
Working with patients	262 (12.0)
Working with customers	340 (15.6)
Participated in an event with ≥50 persons	850 (39.1)
Travelled outside the EU	246 (11.3)
Travelled within the EU	1068 (49.0)
General adherence to public health measures <sup>b</sup>	
Adheres completely to public health measures	1243 (56.9)
Adheres partly to public health measures	919 (42.0)
Adheres little to public health measures	9 (0.4)
Does not adhere to public health measures at all	0 (0.0)
Missing	15 (0.7)
COVID-19 information resource: social media	
Rarely/never	1488 (68.1)
Often/always	686 (31.4)
Missing	12 (0.5)
Trust in COVID-19 information from social media influencer	
Trust	277 (12.7)
No trust	1891 (86.5)
Missing	18 (0.8)
Supporting social distancing in private (contact restriction)	
Yes	1968 (90.0)
No	204 (9.4)
Missing	14 (0.6)
Supporting social distancing in public (at least 1.5 m distance)	
Yes	2126 (97.3)
No	488 (2.2)
Missing	12 (0.5)
Supporting wearing a face mask in public spaces	
Yes	2165 (99.0)
No	13 (0.6)
Missing	8 (0.4)
Supporting the travel restriction	
Yes	1991 (91.1)
No	169 (7.7)
Missing	26 (1.2)

PCR, polymerase chain reaction.

<sup>a</sup> Multiple replies were possible.

<sup>b</sup> In the following analyses, the categories "partly" and "little" were categorised as "partly, adherence to public health measures was assessed by asking respondents.

**Table 3**  
Comparison of different prevalence measures of SARS-CoV-2 antibodies (n = 2186).

Prevalence measure	SARS-CoV-2 seroprevalence (unadjusted, n = 72), % (95% CI)]	SARS-CoV-2 seroprevalence (adjusted <sup>a</sup> , n = 72), % (95% CI)	Participants with neutralising antibodies titres <sup>b</sup> (n = 66), % (95% CI)
Overall seroprevalence	3.3 (2.6–4.1)	3.1 (2.4–4.0)	3.0 (2.4–3.8)
Percentage of those who are seropositive and had a positive PCR before study	2.1 (1.6–2.8)	1.9 (1.4–2.6)	N/A
Percentage of those with neutralising antibody titres and a positive PCR before study	45.5 (34.0–57.4)	45.0 (34.1–57.6)	N/A

CI, confidence interval; N/A, not applicable.

<sup>a</sup> Adjusted for Roche Cobas Elecsys Anti-SARS-CoV-2 test sensitivity and specificity.

<sup>b</sup> Only in case of a positive Roche Cobas Elecsys Anti-SARS-CoV-2 test (n = 66) neutralising antibody titre assay was performed.

OR: 0.91, 95% CI: 0.5–1.5) or for participants who had travelled both within (Table S2; OR: 0.98, 95% CI: 0.6–1.6) and outside (Table S2; OR: 0.72, 95% CI: 0.3–1.8) the EU. Interestingly, no significant associations were found for those aged 20–25 years (OR: 1.27; 95% CI: 0.4–3.9), individuals with a secondary school education (OR: 1.15; 95% CI: 0.4–2.9) and those who worked with patients (OR: 1.12, 95% CI: 0.5–2.4) and customers (OR: 1.36, 95% CI: 0.78–2.38).

*Determinants of an undetected SARS-CoV-2 infection*

Table 4 and Table S2 also show a subgroup analysis of participants who were seropositive but did not report a prior SARS-CoV-2 infection (right column). Because of the small sample size, ORs were not calculated, and the interpretation is based exclusively on the 95% CIs. The analysis showed that undetected infections are about twice as likely in men (2.6%, 95% CI: 1.7–3.99) than in women

**Table 4**  
SARS-CoV-2 seroprevalence in young adults and determinants of infection (n = 2186).

Characteristic	Distribution among seropositive participants	OR for being seropositive unadjusted	OR for being seropositive adjusted for age and sex <sup>a</sup>	Distribution among seropositive participants, but without prior self-reported SARS-CoV-2 infection (positive by PCR) <sup>b</sup>
	% <sup>c</sup> [95% CI]; n	OR [95% CI]	OR [95% CI]	% <sup>c</sup> [95% CI]; n
<b>Sex</b>				
Male	3.8% [2.7–5.3]; 34	Ref <sup>d</sup>	Ref	2.6% [1.7–3.9]; 23
Female	2.7% [1.9–3.7]; 38	0.70 [0.42–1.15]	0.70 [0.42–1.16]	1.3% [0.7–2.0]; 18
Missing (n)	0	–	–	0
<b>Age group</b>				
<20 years	2.7% [0.9–7.0]; 4	Ref	Ref	2.0% [0.6–6.2]; 3
20–25 years	3.4% [2.3–4.9]; 29	1.27 [0.4–3.9]	1.30 [0.6–2.0]	2.2% [1.13–3.5]; 19
26–30 years	2.9% [2.0–4.0]; 37	1.07 [0.4–3.3]	0.94 [0.4–2.0]	1.3% [0.8–2.2]; 18
Missing (n)	2	–	–	1
<b>Household size</b>				
1 person	3.1% [1.9–4.9]; 19	Ref	Ref	1.6% [0.8–3.1]; 10
2 persons	3.2% [2.3–4.6]; 35	1.03 [0.6–1.9]	1.06 [0.6–2.0]	1.8% [1.1–2.9]; 20
≥3 persons	2.8% [1.7–4.6]; 17	0.90 [0.4–1.8]	0.94 [0.6–2.0]	1.6% [0.8–3.1]; 10
Missing (n)	1	–	–	1
<b>Educational level</b>				
Lower/middle	2.7% [1.1–6.5]; 5	Ref	Ref	1.0% [0.1–4.2]; 2
Higher	3.2% [2.4–4.1]; 64	1.15 [0.4–2.9]	1.52 [0.50–4.63]	1.9% [1.2–2.5]; 37
Still a student/other degree	2.3% [0.5–8.4]; 2	0.83 [0.1–5.0]	1.10 [0.17–7.18]	2.3% [0.5–8.4]; 2
Missing (n)	1	–	–	0
<b>Employment status</b>				
Full time	3.1% [2.2–4.3]; 39	Ref	Ref	1.7% [1.1–2.7]; 22
Not working	5.3% [2.3–11.3]; 6	1.73 [0.7–4.3]	1.88 [0.7–4.7]	2.7% [0.8–8.1]; 3
Part-time or reduced working hours	4.1% [1.9–8.4]; 7	1.32 [0.6–3.1]	1.43 [0.6–3.4]	12
Student	2.2% [1.3–3.7]; 17	0.71 [0.4–1.32]	0.71 [0.4–1.3]	1.7% [0.9–3.1]; 13
Missing	3	–	–	4.4% [2.3–21.7]; 1
<b>Migration background</b>				
No	3.2% [2.4–4.1]; 60	Ref	Ref	1.6% [1.1–4.1]; 32
Yes	2.5% [1.3–4.7]; 10	0.79 [0.4–1.62]	0.81 [0.4–1.65]	1.8% [0.7–3.8]; 7
Missing (n)	2	–	–	2

CI, confidence interval; OR, odds ratio.

<sup>a</sup> The estimates for household size, education, employment status and migration background are adjusted for age and sex, the estimate for age is adjusted only for sex and the estimate for sex is adjusted for age only.

<sup>b</sup> For the analysis of subjects with antibodies but without self-reported SARS-CoV-2 infection, subjects with positive PCR test (n = 46) or unknown PCR result (n = 10) were excluded, resulting in a sample size of 2130 participants.

<sup>c</sup> This is the test-adjusted seroprevalence; row-percentages.

<sup>d</sup> Ref = reference category.

(1.3%, 95% CI: 0.7–2.0). The seroprevalence estimate was also considerably higher among individuals who did not adhere to social distancing (2.9%, 95% CI: 1.2–6.3) compared with individuals who adhered to social distancing (1.6%, 95% CI: 1.1–2.3) and among those who seek COVID-19-related information from social media (2.5%, 95% CI: 1.6–4.3) compared with those who did not seek COVID-19-related information from social media (1.3%, 95% CI: 0.8–2.1). The seroprevalence estimate was also higher in individuals who had considered SARS-CoV-2 testing in the past but ultimately did not go ahead with testing. Specifically, while 1.7% of total participants had an undetected infection, 5.0% (95% CI: 2.6–9.1) of those who had considered being tested and 5.4% (95% CI: 2.0–13.3) of those who had not received a test despite requesting one were seropositive. Higher prevalence estimates were also found for individuals who attended an event with >50 people (2.4%, 95% CI: 1.6–3.8) and who travelled outside the EU (2.3%, 95% CI: 0.9–5.1).

## Discussion

In the present study, a test-adjusted SARS-CoV-2 seroprevalence of 3.1% and an underascertainment factor of 1.7 were found among young adults in Germany. Factors significantly associated with SARS-CoV-2 seroprevalence included self-reported symptoms (e.g. loss of smell) and seeking COVID-19-related information from social media. Factors significantly associated with an undetected SARS-CoV-2 infection were being male, not adhering to social distancing and seeking COVID-19-related information from social media.

Compared with estimates from previous national and international studies, the reported seroprevalence and underascertainment rate in the present study are lower than in the general adult population.<sup>24,25</sup> For example, a study from the United States determined a test-adjusted seroprevalence as high as 23% in some counties,<sup>24</sup> and in Germany, Neuhauser et al. reported an underascertainment factor between 2 and 6.<sup>25</sup> There are at least two possibilities that might explain the observed differences. First, most studies focussed on different age groups and specific population groups, such as healthcare personnel.<sup>7,26,27</sup> Furthermore, younger people often experience an asymptomatic or mild SARS-CoV-2 infection, which is associated with lower serum titres.<sup>28</sup> Consequently, it is possible that younger individuals have titres that fall below the threshold of serological assays, and therefore, previous infection may be less frequently detected. Second, the majority of studies were conducted at different times of the pandemic and often in hotspot areas;<sup>10,17,29,30</sup> it should be noted that the timing of the study is crucial, as seroprevalence rates may vary between different pandemic phases. Specifically, many previous seroprevalence studies were performed during the first pandemic wave in spring 2020. In Germany, during this time, significantly fewer PCR tests were performed than during the second wave (starting in November 2020), and therefore, it is likely that at the beginning of the pandemic, a much higher rate of COVID-19 cases remained undetected. Furthermore, it is important to note that to correct the seroprevalence for test sensitivity and specificity, this study applied a conservative approach by using very high sensitivity and specificity values; thus, the corrected seroprevalence is lower than the uncorrected seroprevalence. However, if sensitivity and specificity were below the manufacturer's specification, seroprevalence would be higher and the underreporting rate more distinct. In addition, it has been suggested that antibody titres decline over time.<sup>31</sup> We cannot exclude the possibility that some antibody responses no longer existed by the time of the survey, which would consequently underestimate the seroprevalence.

Potential determinants for seropositivity and undetected infection included self-reported symptoms and seeking COVID-19-related information from social media.

The findings regarding self-reported symptoms are in line with previous reports, which show that a loss of smell and taste, as well as a fever  $\geq 38$  °C were the most strongly associated factors with SARS-CoV-2 seropositivity.<sup>26,32,33</sup> Martínez et al.,<sup>33</sup> for instance, found that fever was among the most frequently described symptoms by seropositive individuals.

The results regarding social media use are novel. Currently, most studies investigating social media use in times of COVID-19 focussed on preventive behaviour in general<sup>34,35</sup> but have not associated it with the actual SARS-CoV-2 seropositivity. Nonetheless, the results are somewhat contradictory to the findings of the present study. For example, Mahmood et al.<sup>34</sup> found that social media use predicts self-efficacy and perceived threat of COVID-19, which, in turn, predicts preventive behaviour. However, in the present study, participants who sought COVID-19-related information from social media were found to be significantly more likely to be seropositive, and undetected cases in this group were almost twice as likely. It is possible that seropositive individuals in the present study viewed content that downplayed the COVID-19 infection risk, which may have led to lower adherence levels to public health measures. However, this remains speculative, as these interrelations could not be detected in the present study. Furthermore, it is important to note that these results may vary over time, might be wave sensitive (i.e. severity of this specific pandemic wave) and depend on information available and consequent knowledge about COVID-19. Nevertheless, social media platforms can play a critical role in the spread of information, particularly in times of crisis, and might impact adherence to public health recommendations.<sup>36,37</sup> Furthermore, given that social media platforms are often the main vehicle for communication among young adults, understanding the dynamics between content consumption and social behaviour may help design more effective communication strategies.

No statistically significant results were found for the association between general adherence to COVID-19 public health measures and seropositivity. However, there was a tendency for seropositivity among individuals who reported that they were in support of social distancing. This may seem surprising at first but could be explained by the fact that adherence to prevention measures was retrospectively assessed. Therefore, information, recall bias and social desirability bias cannot be ruled out.<sup>27</sup> Nonetheless, given that social distancing effectively reduces the risk of transmission and that young adults, despite their often mild disease course, can still spread the virus, they represent a subgroup of the population requiring additional attention from public health campaigns.<sup>38</sup>

The findings suggest that large-scale COVID-19 testing can help to detect more COVID-19 cases. The expansion and continuous development of testing are recommended to secure the containment of the pandemic. Furthermore, vaccination is also essential in younger age groups, especially as recent cross-sectional data from adolescents and young adults found evidence of new or persisting COVID-19 symptoms, such as fatigue, insomnia, headache, concentration difficulties, exercise intolerance and chest pain, 1-month postdiagnosis.<sup>39,40</sup> Vaccinating young adults may, therefore, help prevent the long-term health effects of COVID-19. Furthermore, recent evidence also suggests that vaccination can help reduce the transmission of the disease.<sup>41</sup> Given the high mobility of young adults, increasing immunisation in this population group can help prevent transmission, thereby also protecting vulnerable groups, such as the elderly.

The present study has some limitations that must be noted.

First, we aimed to explore the association between specific (social) determinants and seropositivity, but the subgroups were relatively small, which unfortunately precluded detailed and robust statistical analysis.

Second, the response rate of 24% was lower than that of other seroprevalence studies<sup>17,25</sup> but higher than an epidemiological study conducted in Germany (i.e. NAKO).<sup>42</sup> Nonetheless, the response rates of the other seroprevalence studies are only comparable to a limited extent because different groups were investigated and many studies focussed on hotspot areas.<sup>30</sup> The recruitment period of the present study was short (14 days), resulting in a limited number of individuals being available to participate (i.e. recruitment could not be fully completed in every format [e.g. telephone recruitment attempts]); however, it did enable calculation of SARS-CoV-2 seroprevalence at a specific point in time.

Third, it is impossible to gauge whether study participants were subject to systematic bias because contact could not be established with some invitees. A comparison with the age and gender structure of the population reveals that the net sample is well represented in terms of age, but not gender. Similar to other seroprevalence studies, men were underrepresented.<sup>10,43</sup> However, because men often have a higher seroprevalence and more undetected infections, it is possible that the overall seroprevalence is underestimated in the present study.

Finally, sampling bias may have also occurred. Specifically, the prevalence of COVID-19 infection was higher in this study than the officially reported cumulative prevalence. While the official reported cumulative prevalence among young adults was 1.8%, in the present study, 2.1% of participants reported a prior COVID-19 infection. It is likely that individuals with a prior infection were more sensitised and had an increased interest in participating.

In conclusion, the findings of this study suggest that the SARS-CoV-2 seroprevalence is likely to be much higher than the reported prevalence rates based on confirmed COVID-19 cases. The results further suggest that social media play an important role in young adults' risk perception. Given the limited amount of seroepidemiological data for young adults, a follow-up study to improve the understanding of SARS-CoV-2 seroprevalence and to better identify determinants of a SARS-CoV-2 infection is needed.

## Author statements

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## Ethical approval

The study was approved by the institutional ethics committees of the Medical Faculty of the Heinrich Heine University (reference number: IT-TEMP-2020-1042) and was conducted in line with the Declaration of Helsinki. Study participation was voluntary and could be withdrawn at any time; refusal to participate had no consequences. All participants provided informed written consent.

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## Competing interests

None declared.

## Availability of data and material

The data sets used and/or analysed during the present study can be made available on reasonable request and following the approval of data protection officer of the Heinrich Heine University.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2022.03.009>.

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## Short Communication

## Socio-economic determinants of COVID-19 in Mexico

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## ABSTRACT

**Objectives:** This study aimed to identify and quantify the role that social and economic determinants play in the probability of dying from COVID-19, in the case of Mexico.

**Study design:** This was a cross-sectional study based on secondary data.

**Methods:** In this study, COVID-19 contagion and mortality data were used, as well as socio-economic variables, from public databases and open access, with which an econometric model was estimated.

**Results:** It shows that the number of deaths can rise when variables related to vulnerable groups increase, such as poverty, lack of services, gender, and age. In addition, having pre-existing medical conditions or lacking access to water can be a significant factor in the increase in deaths.

**Conclusions:** Therefore, this study suggests more policies be developed for vulnerable groups to reduce gaps in inequality, particularly given the current situation in which greater inequality can exacerbate the impact of a disease or an unforeseen situation, as is the case of COVID-19.

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## Introduction

Infection from the novel coronavirus (SARS-CoV-2), better known as COVID-19, is associated with acute respiratory symptoms and can become serious.<sup>1</sup> In Mexico, a total of 3,811,793 accumulated cases and 288,733 deaths had been officially confirmed as of November 2021.<sup>2</sup> In addition to the loss of life and the collapse of health systems in countries, the fight against COVID-19 also involves socio-economic challenges for society. The pandemic has made even more visible the socio-economic problems in which society operates and how they can affect the occurrence of a greater or lesser number of cases and deaths. The health emergency has a particularly greater impact on people in vulnerable situations.<sup>1</sup> This vulnerability not only refers to the lack of access to public or private health systems but also to socio-economic determinants such as access to drinking water,<sup>3</sup> poverty,<sup>1</sup> lack of services (education, health, nutrition, and household utilities),<sup>3</sup> inequalities, and pre-existing illnesses,<sup>4</sup> among others.

Research on how the pandemic affects the world's population is under development, and it highly depends on the information that is being generated. With this in mind, the present study was conducted based on the information available to date for the purpose of identifying and quantifying the role that social and economic determinants play in the probability of dying from COVID-19, in the case of Mexico.

## Methods

## Data

The data used in this investigation were obtained from different sources and served as input for constructing a database at the municipal level for the case of Mexico (2,464 municipalities). The information about the accumulated number of infections and deaths from COVID-19 between February 2020 and September 2021 was obtained from the Secretary of Health. The socio-economic information was obtained from the National Institute of Statistics and Geography, the National Institute of Health and Nutrition, and the National Council for the Evaluation of Social Development Policy, through a review of the 2015 Inter-Census Survey, the 2018 National Health and Nutrition Survey, and the

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**Table 1**  
Social and economic determinants of the number of deaths from COVID-19.

Dependent variable		Average	Results from the econometric model		Scenarios—increases in the determinants with their average value as a reference (%)							
Model: ordinary least squares (OLS)			(R <sup>2</sup> = 0.95) (N° = 2,425)		10%	20%	30%	40%	50%	60%	70%	80%
Number of accumulated deaths (DeathsCOVID)		107										
Independent variables			Coefficient	Significance	Increase in the accumulated amount of infections and deaths (%)							
Determinants	No_PipedWater	8.8%	1.2491	0.026	11.3%	12.3%	13.3%	14.4%	15.4%	16.4%	17.4%	18.5%
	Poverty	21,821	0.0006	0.476	13.1%	14.3%	15.5%	16.7%	17.9%	19.1%	20.2%	21.4%
	Vul_Deprivation	13,193	0.0033	0.000	44.7%	48.8%	52.9%	56.9%	61.0%	65.1%	69.1%	73.2%
	Vul_Income	3,838	0.0083	0.000	32.6%	35.6%	38.6%	41.5%	44.5%	47.5%	50.4%	53.4%
	Male	51.3%	0.6558	0.794	34.7%	37.8%	41.0%	44.1%	47.3%	50.5%	53.6%	56.8%
	Older_Adult	12.9%	5.4368	0.000	72.4%	79.0%	85.5%	92.1%	98.7%	105.3%	111.9%	118.5%
	Inc_Elementary	29.2%	2.1517	0.000	64.8%	70.7%	76.6%	82.5%	88.4%	94.3%	100.2%	106.0%
	Pneumonia	0.0146	428.2682	0.150	6.4%	7.0%	7.6%	8.2%	8.8%	9.4%	9.9%	10.5%
	Diabetes	0.0535	303.9750	0.004	16.7%	18.3%	19.8%	21.3%	22.8%	24.4%	25.9%	27.4%
	Hypertension	0.0169	268.6482	0.100	4.7%	5.1%	5.5%	6.0%	6.4%	6.8%	7.2%	7.7%
	Infections	1,391	0.0193	0.000	27.7%	30.2%	32.7%	35.3%	37.8%	40.3%	42.8%	45.3%
	Lack_Health	8,371	0.0033	0.032	28.3%	30.9%	33.4%	36.0%	38.6%	41.1%	43.7%	46.3%
	Density	292.7	0.0311	0.018	9.4%	10.2%	11.1%	11.9%	12.8%	13.6%	14.5%	15.3%

2010 and 2015 Measurement of Poverty on the Municipal Scale, respectively. It is worth mentioning that all the data for this study came from official and public sources that made them available for use. The municipal identifier number (ID) was the variable that united the different sources.

**Model**

An econometric model was estimated based on the municipal database that was constructed, which analyzed the social and economic determinants of the number of deaths from COVID-19 (dependent variable). Regarding this variable, although it can be argued that the data on deaths from COVID-19 are possibly underestimated, this research assumes that the underestimation between municipalities is homogeneous because in the case of Mexico, all the records are carried out by the Secretary of Health; therefore, it should not be a problem for analysis. In addition, the literature review and the socio-economic context of the country indicate that this variable is primarily dependent on the following variables: (1) percentage of occupants in a household without piped water (No\_PipedWater),<sup>3</sup> (2) number of people in poverty (Poverty),<sup>1</sup> (3) number of people who are vulnerable due to social deprivation (Vul\_Deprivation),<sup>5</sup> (4) number of income-vulnerable people (Vul\_Income),<sup>1</sup> (5) percentage of the population that is male (Male), (6) percentage of the population aged ≥60 years (Older\_Adult),<sup>6</sup> (7) percentage of the population aged ≥15 years with incomplete elementary school (Inc\_Elementary),<sup>7</sup> (8) rate of death from pneumonia per 100 inhabitants (Pneumonia), (9) rate of death from diabetes per 100 inhabitants (Diabetes),<sup>4</sup> (10) rate of death from hypertensive diseases per 100 inhabitants (Hypertension), (11) accumulated number of COVID-19 infections (Infections), (12) number of people lacking access to health services (Lack\_Health)<sup>6</sup>, and (13) total population per municipality (Density).<sup>1</sup> The model uses cross-sectional information with the municipalities in

Mexico as the unit of analysis (where municipalities are represented by “i”). In addition, because a discreet dependent variable was involved, the equation was first modeled with a Tobit model, a Poisson model, and an ordinary least squares model, and the latter was chosen because of the robustness of the results—not only of the coefficients but also its interpretation and statistical significance. Finally, a multicollinearity test was performed, ruling out this problem among the independent variables of the model, although they may appear to be correlated.

**Results**

The model estimated presents a global significance of over 0.9, which demonstrates adequate fit with respect to the selection of the independent variables that were included. In addition, the majority of the independent variables (10 of 13 or 77% of these variables) are individually statistically significant (*P* < 0.1). The estimated coefficients of the determinants show that the signs are as expected, that is, an increase in the socio-economic determinants results in an increase in the dependent variable to a lesser or greater extent depending on the determinant. To standardize and compare that increase, based on the estimated coefficients, the possible percentage increases in accumulated number of deaths were estimated using as a reference the average value at the municipal level, given possible percentage increases in the different determinants (Table 1). For example, a 20% increase in the number of income-vulnerable people would result in a 35.6% increase in the accumulated number of deaths from COVID-19 (*P* < 0.01), on average, in each municipality in Mexico.

When analyzing which determinants could more greatly impact the accumulated number of average deaths per municipality, the population aged ≥60 years is in the first place (*P* < 0.01), followed by the population aged ≥15 years with incomplete elementary education (*P* < 0.01), and third, those who are vulnerable due to

$$\text{Model : DeathsCOVID}_i = \beta_1 \text{No\_PipedWater}_i + \beta_2 \text{Poverty}_i + \beta_3 \text{Vul\_Deprivation}_i + \beta_4 \text{Vul\_Income}_i + \beta_5 \text{Male}_i + \beta_6 \text{Older\_Adult}_i + \beta_7 \text{Inc\_Elementary}_i + \beta_8 \text{Pneumonia}_i + \beta_9 \text{Diabetes}_i + \beta_{10} \text{Hypertension}_i + \beta_{11} \text{Infections}_i + \beta_{12} \text{Lack\_Health}_i + \beta_{13} \text{Density}_i + \varepsilon_i$$

social deprivation ( $P < 0.01$ ). That is, the likely greater impact on an increase in the amount of deaths could be primarily due to increased issues related to vulnerable groups, including poverty, social deprivation, gender, and age. Other factors that could directly affect the increased number of deaths from this disease, to a lesser degree, are a larger amount of people who lack access to health services ( $P < 0.05$ ), a higher number of COVID-19 infections ( $P < 0.01$ ), and greater density ( $P < 0.05$ ).

Nonetheless, COVID-19 is a coronavirus that has different effects depending on each person. For the majority of the people who get infected, the intensity of the symptoms is slight to moderate, and they recover without the need for hospitalization. Nevertheless, it can be a serious disease, particularly for older adults or people with pre-existing medical conditions or comorbidities, such as diabetes, heart disease, high blood pressure, pneumonia, and asthma, among others. For the case of Mexico, the results predict that, for example, an increase of 30% in the death rate per 100 inhabitants for cases of high blood pressure ( $P < 0.01$ ), pneumonia, or diabetes ( $P < 0.01$ ) would result in an average increase in the number of accumulated deaths per municipality of 5.5%, 7.6%, and 19.8%, respectively; that is, of the three comorbidities included in the analysis, diabetes would more greatly impact the accumulated number deaths.

Finally, the use of facemasks and handwashing with soap and water are considered crucial for being able to reduce or prevent the spread of COVID-19. In the case of the municipalities in Mexico, the data indicate that, for example, a 20% increase in occupants in a household without water would result in a 13.3% increase in average accumulated cases of death from COVID-19 per municipality. This demonstrates that household access to water is crucial for fighting this illness, as are the other socio-economic variables.

## Discussion and conclusion

Death from COVID-19 appears to be statistically significantly associated with socio-economic and health determinants at the municipal level in Mexico, and these relationships can be more pronounced when analyzed by type of determinant. The population living in conditions without access to piped water, older adults aged  $\geq 60$  years, people with incomplete elementary education, those who live in poverty, and those with comorbidities, such as diabetes, can have a greater risk of dying from COVID-19. Thus, decision-makers should more closely consider several variables that are important for public policies, including the large gap in socio-economic inequality, the high prevalence of comorbidities, the existence of regions, and social groups that are highly vulnerable because of their socio-economic situation, access to more high-quality public services, and the reduced institutional capacity. These factors are especially important in situations such as the

current one, where an increase in these variables can more greatly exacerbate the impact that the presence of another disease or unforeseen outbreak can have on society, as is the case of COVID-19.

## Author statements

### Ethical approval

Ethical approval was not required for this study.

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### Competing interests

None declared.

### Data availability

Data were obtained from an open-access database.

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## Original Research

## Socio-economic inequalities in physical activity among Japanese adults during the COVID-19 pandemic

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## ABSTRACT

**Objectives:** This study aimed to explore the socio-economic inequalities in physical activity (PA) based on domains of daily life, such as work, transport, recreation and sedentary life, among Japanese adults during the COVID-19 pandemic.

**Study design:** This was a cross-sectional study.

**Methods:** This study used data from the 2020 National Sport and Lifestyle Survey, conducted by the Sasakawa Sports Foundation. Data of 2,296 (1,103 women) participants were analysed. PAs were assessed using the Global Physical Activity Questionnaire. Educational level and household income were used as indicators of socio-economic status. We calculated the slope index of inequality (SII) and relative index of inequality (RII).

**Results:** We detected absolute and relative inequalities for household income in all PA domains, except for work-related PA. The higher the participants' income, the longer they engaged in transport- and recreation-related PA and sedentary behaviour. Recreation-related PA had a larger disparity than other domains, with SII at 20.8% (95% confidence interval [CI] –28.4 to –13.1) and RII at 0.58 (95% CI 0.47–0.71). At the educational level, each inequality was observed in work- and recreation-related PA and sedentary behaviour. The higher the participants' educational level, the longer they engaged in recreation-related PA and sedentary behaviour. However, work-related PA was longer at lower educational levels, with RII at 1.90 (95% CI 1.48–2.44). The inequality in recreation-related PA was also relatively large (SII 23.3%, 95% CI –30.9 to –15.7; RII 0.54, 95% CI 0.45–0.66).

**Conclusion:** Our study revealed significant socio-economic disparities in each PA domain, particularly in recreational PA. These results suggest a widening gap because of the COVID-19 pandemic.

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## Introduction

Since the first report of a novel COVID-19 in Wuhan, China, in December 2019, the number of infections has continued to rise. Despite dedicated efforts to end the pandemic, including vaccination and antiviral therapies based on blood products and antibodies, the emergence of different variants causing new infections has made the prevailing situation extremely complicated.<sup>1</sup> As of September 2021, the number of infected people in 210 countries reached 230 million, and the estimated number of deaths was more than 4.7 million.<sup>2</sup>

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Various measures have been taken in Japan to reduce the risk of infection, including the cancellation of large-scale events, school closures and requests to refrain from leaving the house or closing the office due to a declared state of emergency.<sup>3</sup> These restrictions have contributed to people's inactivity<sup>4–9</sup> and affected the economy and industry. The service industry, including the restaurant and tourism industries, experienced a significant drop in sales, and many businesses were forced into unemployment and bankruptcy.<sup>10,11</sup> However, the information and communication industry, including online businesses, saw an increase in sales.<sup>10,11</sup> This disparity in sales among industries, which had been a concern even before the COVID-19 pandemic, has been exacerbated by the pandemic.<sup>10,11</sup>

Social and economic disparities have been a concern, as they contribute to health or health behaviour disparities.<sup>12–14</sup> Low socio-economic status (SES) people are at increased risk of premature

cardiovascular and all-cause mortality compared to high SES people.<sup>12–14</sup> Physical activity (PA) is a health behaviour that shows different disparities in each domain. An umbrella review<sup>15</sup> reported a relationship between PA and SES, especially in relation to leisure time (positive relationship) and occupational PA (negative relationship). Although most literature included in this review is from Western countries, Japan is no exception. Matsushita et al.<sup>16</sup> surveyed 3269 Japanese adults aged 30–59 in 2014 and reported that Japanese men with an annual household income of  $\geq 7$  million yen had 1.96 times lower work-related PA; conversely, 1.89 times greater recreational PA than the lowest income (<3 million yen) group. They also reported that women with higher income had 1.43 times greater recreational PA. Similar findings have been reported in other Japanese studies.<sup>17–20</sup>

There has been concern that the changing lifestyle associated with the COVID-19 pandemic has exacerbated existing disparities.<sup>21</sup> Taking the example of the differences in transferability between industries in regard to telework, we can presume that work-related PA is higher among low SES people, and physically inactive or sedentary behaviour (SB) is higher among high SES people. A previous New Zealand study reported that population movement was higher in areas with high neighbourhood deprivation.<sup>22</sup> However, to the best of our knowledge, there has been no investigation of socio-economic inequality in PA among the adult population during the COVID-19 pandemic at the individual level.

The Japanese government has requested a 70% reduction in the number of people coming to work, and telework has been encouraged.<sup>3</sup> While the Ministry of Internal Affairs and Communications in Japan had already been promoting telework, the proportion of teleworking has increased due to the COVID-19 pandemic.<sup>23</sup> In this context, differences in transferability between blue- and white-collar workers' workstyles are also a concern. Lower SES has been linked to a lesser likelihood of individuals holding occupations in which working from home is possible.<sup>21,24</sup> Although there are no representative data on the proportion of occupational categories shifting to teleworking in Japan, a disparity in educational background among occupations was noted before the pandemic.<sup>25</sup> The percentage of people with low educational attainment is high among blue-collar workers, such as manufacturing and restaurant workers.<sup>25</sup> However, most white-collar workers, such as those working in the communication and information industry, are highly specialised workers.<sup>25</sup> For example, according to the national census in 2010,<sup>26</sup> among manufacturing workers, the percentage of those whose education level was high school graduate or below was approximately 62%, whereas this percentage among those in the information industry was 21%. Because educational background and income are correlated,<sup>13</sup> low SES people are less likely to be able to telework. Given this, the pandemic seems to have widened the SES disparity in telework, which, in turn, has widened the SES disparity in work–life balance.

Numerous health benefits of PA have been extensively documented.<sup>27–30</sup> Sufficient PA is known to be associated with a substantially reduced risk of all-cause and disease-specific mortality<sup>30</sup> and prevention of multiple chronic diseases (i.e. metabolic syndrome, type 2 diabetes, cancer and cardiovascular disease)<sup>27,28</sup> and mental disorders.<sup>31,32</sup> Until recently, the health benefits of engaging in different domains of PA (leisure time, work, household and transport) have been considered to be positive and alike. Thus, workers who are physically active at work could be expected to be healthier and live longer.<sup>33</sup> However, it has been suggested that accumulated occupational PA may pose a health risk,<sup>34</sup> in contrast to the health benefits of recreational PA. A systematic review reported that those engaging in high (compared with low) occupational PA have an 18% increased risk of all-cause mortality.<sup>35</sup> This

has become controversial as the PA paradox,<sup>34</sup> signifying the growing need to investigate PAs on a domain-by-domain basis.

Understanding the inequalities in PA based on domains during this pandemic is important for effective intervention strategies. Therefore, the present study aimed to explore the socio-economic inequalities in PA stratified by work, transport and recreation among adults during the COVID-19 pandemic.

## Methods

### Data source

This study used data from the 2020 National Sport and Lifestyle Survey conducted by the Sasakawa Sports Foundation (SSF).<sup>36</sup> The National Sport and Lifestyle Survey is a nationwide cross-sectional survey that has been conducted every 2 years since 1992. The survey mainly measures participation in sports and PAs, sports spectating, sports volunteering and personal attributes of individuals aged  $\geq 18$  years and living in Japan. Data were collected using self-administered questionnaires between August and September of 2020.

The study sample was selected using the quota method from 300 locations (89 in metro areas, 122 in cities with a population of over 100,000 people, 64 in cities with a population of less than 100,000 people, and 25 in towns and villages), which were proportionally distributed from the strata by district/city size based on the population of the basic resident register. The target sample size allocated to each location was set at 10. A total of 3,000 individuals participated in the survey. After excluding individuals with missing variables of interest, data from 2,296 (1,193 men and 1,103 women) participants were used for analysis.

Detailed information on the survey methods can be found elsewhere.<sup>36</sup> Ethical approval was not required, as this study was a secondary analysis conducted using public data sets from the SSF that did not include identifiable personal information.

### COVID-19-related situation and measures in Japan during the survey period

During the survey period, Japan was amidst the second wave of infection spread.<sup>37</sup> Although no strong administrative measures such as the declaration of a state of emergency were taken, the government issued an advisory termed New Lifestyle, which called for people to refrain from activities to prevent infection.<sup>38</sup> Its content includes behavioural restrictions such as 'avoiding three Cs (avoiding gatherings in closed, crowded, and close-contact settings)' and refraining from going out unnecessarily as well as a recommendation to telework.<sup>38</sup> In some areas where the infection has spread, administrative measures continued to be taken, such as requesting that restaurants shorten their operations or engage in temporary closures and limiting the number of people at large-scale events.<sup>39</sup>

### Measures

In the 2020 survey, PAs in daily life were assessed using the Global Physical Activity Questionnaire version 2 (GPAQ). The GPAQ was developed by the World Health Organization (WHO),<sup>40</sup> and its validity and reliability have been verified.<sup>41,42</sup> Participants were assessed for time spent per week engaging in moderate-to-vigorous PA in three different domains: activity at work, travel to and from places and recreational activities. We calculated metabolic equivalent (MET) minutes per week engaged in PA according to the GPAQ analysis guide.<sup>40</sup> If the participants did not engage in at least 600 MET minutes of PA per week, they were classified as



performing insufficient PA (i.e. not meeting WHO PA guidelines).<sup>43</sup> Engaging in work-, transport-, or recreation-related PA was defined as undertaking more than 0 MET minutes of PA in these domains.<sup>44</sup> The participants were also assessed in regard to the time spent sitting in a typical day. If the participants sat for 8 h or more per day, they were classified as sitting too much.<sup>45</sup>

SES indicators included income and educational level. The participants were asked their annual pretax household income using 11 options ranging from ‘no income’ to ‘10 million yen or more’. The ‘I don’t know’ option was deemed a missing case. The midpoint of each option was substituted for the household income. The equivalent household income was calculated by dividing household income by the square root of the number of members in the household.<sup>46</sup> Subsequently, the equivalent household income was categorised based on one-half of the median equivalent household income as a cut-off point: ‘less than 1.375 million yen’, ‘1.375 to less than 2.75 million yen’, ‘2.75 to less than 5.5 million yen’ and ‘5.5 million yen or more’.<sup>47,48</sup> One million yen was roughly 10,000 US dollars. Participants’ educational level was measured as the highest level of education attained and was classified into three categories: ‘high school or less’, ‘junior or vocational college’ and ‘university or more’.

Sex, age group, place of residence, self-rated health and body mass index were used as covariates, which were considered as potential confounders. The place of residence was categorised into four groups based on urban size, as mentioned previously. Self-rated health was dichotomised into ‘good’ and ‘poor’. Body mass index was calculated using self-reported height and weight.

**Table 1**  
Prevalence of physical activity by setting.

Characteristic	N (%)	Not meeting WHO PA guidelines		Engaging in work-related PA		Engaging in transport-related PA		Engaging in recreation-related PA		Sedentary behaviour (≥8 h/d)	
		n (%)	P <sup>a</sup>	n (%)	P <sup>a</sup>	n (%)	P <sup>a</sup>	n (%)	P <sup>a</sup>	n (%)	P <sup>a</sup>
Total	2296 (100)	1037 (45.2)		647 (28.2)		1071 (46.6)		859 (37.4)		623 (27.1)	
Sex											
Men	1193 (52.0)	482 (40.4)	<0.001	396 (33.2)	<0.001	527 (44.2)	0.014	480 (40.2)	0.004	354 (29.7)	0.004
Women	1103 (48.0)	555 (50.3)		251 (22.8)		544 (49.3)		379 (34.4)		269 (24.4)	
Age group (y)											
18–29	253 (11.0)	93 (36.8)	0.036	90 (35.6)	<0.001	150 (59.3)	<0.001	91 (36.0)	0.018	81 (32.0)	0.040
30–39	354 (15.4)	161 (45.5)		120 (33.9)		159 (44.9)		111 (31.4)		81 (22.9)	
40–49	484 (21.1)	221 (45.7)		159 (32.9)		202 (41.7)		182 (37.6)		140 (28.9)	
50–59	419 (18.2)	180 (43.0)		106 (25.3)		181 (43.2)		177 (42.2)		127 (30.3)	
60–69	424 (18.5)	208 (49.1)		101 (23.8)		183 (43.2)		148 (34.9)		106 (25.0)	
70+	362 (15.8)	174 (48.1)		71 (19.6)		196 (54.1)		150 (41.4)		88 (24.3)	
Self-rated health											
Bad	543 (23.6)	277 (51.0)	0.002	151 (27.8)	0.826	236 (43.5)	0.089	172 (31.7)	0.002	179 (33.0)	<0.001
Good	1753 (76.4)	760 (43.4)		496 (28.3)		835 (47.6)		687 (39.2)		444 (25.3)	
Residence area											
21 metropolises	716 (31.2)	279 (39.0)	<0.001	189 (26.4)	0.473	428 (59.8)	<0.001	284 (39.7)	0.354	192 (26.8)	.635
Cities population 100,000+	926 (40.3)	414 (44.7)		274 (29.6)		429 (46.3)		341 (36.8)		262 (28.3)	
Cities population <100,000	478 (20.8)	240 (50.2)		138 (28.9)		156 (32.6)		176 (36.8)		120 (25.1)	
Towns and villages	176 (7.7)	104 (59.1)		46 (26.1)		58 (33.0)		58 (33.0)		49 (27.8)	
Body mass index (kg/m <sup>2</sup> )											
<18	178 (7.8)	90 (50.6)	0.306	44 (24.7)	0.288	95 (53.4)	0.014	44 (24.7)	0.001	40 (22.5)	0.331
18–25.0	1637 (71.3)	735 (44.9)		456 (27.9)		776 (47.4)		630 (38.5)		448 (27.4)	
25.0+	481 (20.9)	212 (44.1)		147 (30.6)		200 (41.6)		185 (38.5)		135 (28.1)	
Equivalent household income (million yen)											
<1.375	263 (11.5)	137 (52.1)	<0.001	58 (22.1)	0.100	120 (45.6)	0.024	77 (29.3)	<0.001	66 (25.1)	0.014
1.375–2.75	882 (38.4)	429 (48.6)		252 (28.6)		380 (43.1)		295 (33.4)		215 (24.4)	
2.75–5.5	1029 (44.8)	433 (42.1)		305 (29.6)		515 (50.0)		420 (40.8)		298 (29.0)	
5.5+	122 (5.3)	38 (31.1)		32 (26.2)		56 (45.9)		67 (54.9)		44 (36.1)	
Educational level											
High school or less	1118 (48.7)	520 (46.5)	0.418	343 (30.7)	0.007	509 (45.5)	0.125	356 (31.8)	<0.001	276 (24.7)	<0.001
Junior or vocational college	528 (23.0)	235 (44.5)		150 (28.4)		237 (44.9)		202 (38.3)		120 (22.7)	
University or high	650 (28.3)	282 (43.4)		154 (23.7)		325 (50.0)		301 (46.3)		227 (34.9)	

PA, physical activity; WHO, World Health Organization.

<sup>a</sup> Chi-squared test.

### Statistical analysis

Differences in the proportion of each PA domain among different groups in terms of each independent variable were compared using the Chi-squared test.

Socio-economic inequalities in each PA domain were assessed using absolute and relative measures. For the absolute measure, we calculated the slope index of inequality (SII)<sup>49,50</sup> using generalised linear models with binomial distribution and identity link functions.<sup>51</sup> For the relative measure, we calculated the relative index of inequality (RII)<sup>49,50</sup> using generalised linear models with a binomial distribution and log link function.<sup>51</sup> The SII and RII were estimated using the ridit score for each SES indicator as an independent variable. SII and RII are summary measures of inequality represented as the changes in PA between the bottom and top points in the SES hierarchy while accounting for the cumulative distribution in each SES.<sup>52</sup> Finally, these models were adjusted for the covariates.

### Results

Table 1 shows the differences in the proportion of each PA domain among different groups for each independent variable. According to Chi-squared test tests, equivalent household income was associated with insufficient WHO PA recommendation level, engaging transport- and recreation-related PAs and prolonged SB, whereas education level was associated with less engaging work-related PA, engaging recreation-related PA and prolonged SB.

Table 2 shows the SII and RII in PA by domain for each SES indicator. Both inequalities for household income were observed in

**Table 2**  
SII and RII in each physical activity domain.

Variables	Not meeting WHO PA guidelines		Engaging in work-related PA		Engaging in transport-related PA		Engaging in recreation-related PA		Sedentary behaviour (≥8 h/d)	
Household income										
Crude SII (95% CI)	18.0	(10.4, 25.6)	−5.5	(−12.5, 1.5)	−9.0	(−16.6, −1.3)	−20.7	(−28.0, −13.5)	−9.8	(−16.5, −3.1)
Adjusted SII (95% CI) <sup>a</sup>	14.2	(6.2, 22.2)	−3.2	(−10.2, 3.8)	−10.8	(−18.5, −3.1)	−20.8	(−28.4, −13.1)	−10.1	(−17.1, −3.0)
Crude RII (95% CI)	1.473	(1.25, 1.74)	0.830	(0.66, 1.05)	0.824	(0.70, 0.97)	0.560	(0.46, 0.69)	0.684	(0.53, 0.89)
Adjusted RII (95% CI) <sup>a</sup>	1.344	(1.13, 1.60)	0.996	(0.77, 1.28)	0.824	(0.70, 0.97)	0.575	(0.47, 0.71)	0.681	(0.52, 0.89)
Educational level										
Crude SII (95% CI)	5.1	(−2.5, 12.8)	10.9	(4.0, 17.7)	−6.2	(−13.9, 1.5)	−22.8	(−30.2, −15.4)	−13.5	(−20.3, −6.8)
Adjusted SII (95% CI) <sup>a</sup>	0.1	(−7.7, 7.8)	14.9	(8.1, 21.6)	−6.4	(−14, 1.2)	−23.3	(−30.9, −15.7)	−12.4	(−19.5, −5.4)
Crude RII (95% CI)	1.121	(0.95, 1.33)	1.471	(1.15, 1.89)	0.875	(0.74, 1.03)	0.546	(0.45, 0.66)	0.593	(0.46, 0.77)
Adjusted RII (95% CI) <sup>a</sup>	0.991	(0.83, 1.18)	1.901	(1.48, 2.44)	0.912	(0.78, 1.07)	0.544	(0.45, 0.66)	0.585	(0.45, 0.75)

CI, confidence interval; PA, physical activity; SII, slope index of inequality (%); RII, relative index of inequality; WHO, World Health Organization.

<sup>a</sup> Adjusted for sex, age group, place of residence, self-rated health, and body mass index.

all PA domains, except for work-related PA. In particular, recreation-related PA had a larger disparity than other domains, with adjusted SII at −20.8% (95% CI, −28.4 to −13.1), and adjusted RII at 0.58 (95% CI, 0.47–0.71). Disparities in adherence to WHO PA guidelines (adjusted SII, 14.2%, 95% CI, 6.2–22.2; adjusted RII, 1.34, 95% CI, 1.13–1.60) and excessive prolonged SB (adjusted SII, −10.1%, 95% CI, −17.1 to −3.0; adjusted RII, 0.68, 95% CI, 0.52–0.89) were also observed. At the educational level, each inequality was observed in work-related PA, recreation-related PA and SB. Consistent with the inequalities of household income, the inequality in recreation-related PA was relatively large (adjusted SII, −23.3%, 95% CI, −30.9 to −15.7; adjusted RII, 0.54, 95% CI, 0.45–0.66). The relative inequalities (adjusted RII) in work-related PA and SB were also high at 1.90 (95% CI, 1.48–2.44) and 0.59 (95% CI, 0.46–0.77), respectively. The crude models showed the same results as the adjusted models, which adjusted for sex, age group, place of residence, self-rated health and body mass index.

## Discussion

This is the first study to examine the socio-economic inequalities in PA by domains of daily life among the Japanese adult population during the COVID-19 pandemic. We found that those with lower household income and educational levels had lower recreational PA. Conversely, those with higher household income and educational levels likely had a longer sitting time. In addition, those with lower household income likely had a lower proportion of meeting WHO PA guidelines and transport-related PA. Moreover, those with lower educational levels likely had higher work-related PA.

We demonstrated a large economic disparity in compliance with the WHO PA recommendation, although the association showed mixed results (negative, null, or positive association) among Japanese adults before the pandemic.<sup>16,19,53–55</sup> It may be the case that the COVID-19 pandemic has widened the economic inequality of total PA. This is probably because of the expanded disparity in recreational PA.

Numerous studies have pointed out the economic disparity in recreational PA before the COVID-19 pandemic in both Western countries<sup>15</sup> and Japan.<sup>16–18,20</sup> However, the results of one study examining secular trends in economic disparity among Japanese PAs using the SII and RII<sup>48</sup> only partially confirmed this disparity. Although a direct comparison is not possible because their sample and household income categories are different from ours, a wider gap may be observed.

Our findings showed that recreational PA was also affected by educational disparities. Previous studies before the pandemic examining the association between educational level and

recreational PA indicated mixed results.<sup>16–18,56,57</sup> Murakami et al.<sup>18</sup> cited the human capital model of health investment<sup>58,59</sup> and explained the disparity of education and income in exercise habits from the following perspectives: individuals invest in their existing health stock to prevent economic loss due to illness or derive satisfaction from enjoying health itself, a higher wage income would motivate a working individual to engage in habitual exercise because of their desire to avoid ill health and a loss of wages, and more educated people are more efficient producers in terms of health stock because they acquire better skills and knowledge. Based on this hypothesis, we speculate that the higher SES population, which had already been motivated to engage in health behaviours before the pandemic, became more aware of the need to maintain and improve their health in the face of behavioural restrictions. Indeed, an Internet-based survey conducted by the Japan Sports Agency on 9,000 Japanese individuals between the ages of 6 and 69 years reported that awareness and practice of exercise were improved during the COVID-19 pandemic.<sup>60</sup> Murakami et al.<sup>18</sup> also refer to time constraints, that is, conflict with hours of labour participation. This means that the longer the people work, the less time they have to exercise. The combination of changes in working style due to the pandemic (shifting to telework, stay-at-home advisories and unemployment due to requests for closure by the government) and time constraints may have made socio-economic disparity more apparent in recreational PA.

We infer that the change in working style due to the pandemic would also explain the disparity in work-related PA and SB. Economic disparities in work-related PA detected as of 2014<sup>16</sup> were not observed in this study. Occupations that have seen an increase in the number of unemployed or have received requests for temporary closures from the government include those in the manufacturing, retail, restaurant, lodging and service industries.<sup>10,11</sup> The average annual salary for these occupations is the lowest in Japan by industry.<sup>61</sup> Although the exact cause remains a matter of conjecture because the status of unemployment for the participants was not surveyed, it is possible that a certain number of low SES people lost their jobs, resulting in a lack of economic disparity in work-related PA.

Regarding the educational disparity in work-related PA, one possible reason is that many occupations with highly educated people are shifting to teleworking. Fukushima et al.<sup>4</sup> revealed that moderate-to-vigorous PA times were significantly shorter (35 min) in the telework group than in the non-telework group. Occupations that continue to require onsite work during the COVID-19 pandemic include manufacturing, where there are many less educated workers.<sup>25</sup> Thus, this difference in work-related PA due to the characteristics of the occupation probably appears as an educational disparity.

Our study also found educational and economic inequalities in SB. This may also be related to the fact that occupations with many highly educated people have shifted to telework. Although it is well known that workplace environment affects PA and SB,<sup>62</sup> Fukushima et al.<sup>4</sup> reported that during the COVID-19 pandemic, SB time among teleworkers was over 100 min longer than among teleworkers during the pandemic.<sup>4</sup> Few studies have examined the association between SES and SB.<sup>63</sup> As telework is being promoted now, more heavily than ever,<sup>64</sup> there is a need to monitor whether inequalities will continue to widen.

Consistent with a previous Japanese study,<sup>16</sup> an association between economic status and transport-related PA was found. However, the results of the Chi-squared test indicate that this association reflects the difference between the middle two economic categories, not the lowest and highest categories. It tends to be different from associations in other PA domains and from the results of previous studies. In an umbrella review,<sup>15</sup> the relationship between SES and transport-related PA was inconsistent, and the influence of environmental factors, such as connectivity and the availability of public transport, was highlighted.<sup>65</sup> This may also be affected by increased health awareness in the high SES population<sup>60</sup> and behavioural restrictions caused by COVID-19; however, the precise reason for this result is not clear. More comprehensive research, including examining environmental factors, is required.

According to a Japanese study in 2014 that investigated the association between SES (annual household income, educational level and employment status) and PA using the GPAQ, the proportions of inactivity in total, work, travel and recreation PA were 55.5%, 83.5%, 55.0% and 74.5%, respectively.<sup>16</sup> Our results demonstrated proportions of 45.2%, 71.8%, 53.4% and 62.6%, respectively, highlighting an improvement. As the previous study was not conducted shortly before COVID-19 and did not include the same participants, we must interpret it with caution. Meanwhile, this trend accords with an Internet survey conducted by the Japan Sports Agency.<sup>60</sup> This trend is probably observed because COVID-19 has made people more aware of the importance of exercise. An analysis of big data using Google Trends indicated that public awareness of movement increased sharply after the state of emergency for COVID-19 in Japan.<sup>66</sup> The same trend has been observed in the United Kingdom, the United States and Australia.<sup>67</sup>

However, our findings indicate that such Internet-based information is biased towards populations that have sufficient resources to use the Internet, and overall results do not reflect all layers of subgroups, including SES. In fact, the sample of the Japan Sports Agency<sup>60</sup> is not representative as the distribution of SES is skewed towards the higher end of the spectrum compared with that of the National Survey on Living Standards, which is the standard for the entire population.<sup>68</sup> Overall, our study revealed that high SES indicates higher recreational PA but longer SB, whereas those with low SES show the opposite. We need to continue to monitor how this affects health in the short term and long term and provide necessary support to vulnerable populations.

### Limitations

We cannot take into account any psychological factors (e.g. self-efficacy and motivation), which were identified as having an independent influence on PA before COVID-19 because of lack of data. As it is unlikely that these factors affect PA similarly during restrictions that require to staying at home,<sup>21</sup> further studies exploring comprehensive factors are needed.

PA was measured using a questionnaire, whereas objective measurements are generally recommended. Thus, the prevalence of inactivity might be underestimated due to social desirability bias or recall bias. However, using the data of the GPAQ, which has been

standardised and used worldwide, allowed us to assess the inequalities in domain-specific PA and compare our results to data within a country before the pandemic.

Finally, our findings could not be regarded as universal evidence, as PA is sensitive to changes in the social system, physical environment and culture in each country. Therefore, further studies are required in other countries.

### Author statements

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#### Ethical approval

Ethical approval was not required, as this study was a secondary analysis conducted using public data sets from the SSF that did not include identifiable personal information.

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#### Competing interests

The authors declare no other conflicts of interest.

#### Author contribution

All authors contributed to the concept or design of the study and the acquisition, analysis, or interpretation of data for the work. A.K. drafted the article. M.T. critically revised the article. All authors gave final approval and agreed to be accountable for all aspects of work, thus ensuring integrity and accuracy.

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## Original Research

## Understanding the societal factors of vaccine acceptance and hesitancy: evidence from Hong Kong

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## ABSTRACT

**Objectives:** Vaccination is considered to be an important public health strategy for controlling the COVID-19 pandemic. Besides subjective evaluations of the vaccine and the health threat, societal factors have been seen as crucial to vaccination decisions. Based on a socioecological perspective, this study examines the role of societal factors in COVID-19 vaccine hesitancy in Hong Kong.

**Study design and method:** An online survey was fielded between 25 and 28 June 2021, collecting 2753 complete responses. Multinomial logistic regression was conducted to examine how subjective evaluations of the vaccine (summarised by the 5C model – Confidence, Collective responsibility, Constraints, Complacency and Calculation), threat perception, interpersonal influences and institutional trust contribute to explaining three types of decision – *acceptant* (vaccinated, scheduled or indicated ‘Yes’), *hesitant* (unvaccinated and indicated ‘Maybe’ on intention) and *resistant* (unvaccinated and indicated ‘No’).

**Results:** A total of 43.2%, 21.7% and 35.1% of respondents were acceptant, hesitant and resistant. Although the 5C model remained useful in explaining vaccination decisions, respondents were heavily influenced by the decisions of their family, although they were less influenced by friends. Second, respondents tended to accept the vaccine when they had a weaker perception that the act is supportive of the government and were less resistant if they had stronger institutional trust.

**Conclusion:** Under the low-incidence and low-trust environment such as Hong Kong, vaccination decisions are heavily influenced by family’s decision and the perception of vaccination as socially and politically desirable. Our findings highlight the importance of a nuanced conception of interpersonal and political influence towards vaccine acceptance/hesitancy.

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## Introduction

Despite strenuous efforts worldwide to promote COVID-19 vaccination, many countries are struggling with vaccine hesitancy.<sup>1–9</sup> Previous research has suggested factors influencing hesitancy to different vaccines (e.g. influenza, human papillomavirus and measles), including demographic characteristics, health beliefs, norms, economic and political contexts and vaccine attributes.<sup>1,10,11</sup> A commonly used framework is the 5C model,<sup>12</sup> which highlights

psychological antecedents, including attitudes (confidence), perceived invulnerability (complacency), perceived barriers (constraints), preference for deliberation (calculation) and communal orientation (collective good). The model was found efficacious in predicting the acceptance of COVID-19 vaccination in healthcare workers,<sup>13,14</sup> community-dwelling adults,<sup>15</sup> and university students during COVID-19 outbreaks.<sup>16</sup> On top of these five ‘Cs,’ Geiger et al.<sup>17</sup> added two more ‘Cs’—conspiratorial thinking and compliance with social monitoring and sanctioning for non-adherence—to highlight the social nature of decision-making for COVID-19 vaccination. Their findings call for deepened understanding of how societal factors shape COVID-19 vaccination decisions. Hence, based on a socioecological framework,<sup>18–20</sup> this study examined the role of two societal factors, namely, interpersonal influences and trust towards public institutions.

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Pre-COVID-19 studies found that influences from one's family, friends and the community are crucial in determining vaccination decisions.<sup>18,21–25</sup> For COVID-19, as a high vaccination rate is needed for effective protection for a community, interpersonal influences will be pivotal in motivating vaccination, especially among people with disparate levels of perceived vulnerability and when the incidence of COVID-19 may be low at that moment, giving people a false sense of safety. Although studies have examined interpersonal influences on preventive behaviours, such as mask-wearing, under the COVID-19,<sup>26,27</sup> few have targeted vaccination as an invasive behavioural outcome, especially during a mass roll-out.

The second type of societal factor concerns attitudes towards the authority that administers the vaccination programme.<sup>28,29</sup> Trust is crucial to the compliance with COVID-19 containment policies,<sup>30,31</sup> which often require government emergency powers and limit civic freedom. As governments have rolled out COVID-19 vaccines under emergency use authorisation, attitudes towards the governments would be crucial to the receptiveness of such brand-new vaccines, especially against the backdrop of their safety and side-effect concerns.<sup>32</sup> Attitudes on COVID-19 vaccination have been divided by political partisanship, and the behaviour is seen as politicised in politically polarised states.<sup>33–35</sup> However, what or who is being distrusted (or trusted) – for example, the government system or the political parties – awaits clarification.

Hong Kong provides a useful case for investigating how societal determinants contribute to COVID-19 vaccine hesitancy. Shortly after COVID-19 vaccines were approved by COVAX, the Hong Kong government managed to procure sufficient vaccines for all adult citizens by February 2021. However, vaccine uptake was slow in the first few months. Local surveys conducted shortly before the mass vaccination programme found only about 40% of the adult population intended to be vaccinated.<sup>36,37</sup> Five months into the programme, as of 1 September 2021, only 46% of the population was fully vaccinated, falling dramatically behind major countries, including the United Kingdom, Canada and Singapore, despite nearly no vaccine supply issues.<sup>8,9</sup>

Two reasons may account for Hong Kong's vaccine hesitancy. First, the low incidence of COVID-19 under the government's zero tolerance policy and the high compliance with mask-wearing<sup>38</sup> might have mitigated citizens' perceived infection risks, reducing the effects of threat appraisal. Second, trust in the government had plummeted after the citywide protests in 2019 sparked off by the introduction of the extradition law amendment bill. The lack of trust was reflected in the early months of the pandemic when citizens relied heavily on civil society mobilisation to source masks and pressure the government to close the city's borders.<sup>39,40</sup> Thus, when the vaccination programme was introduced, it was quickly shrouded in scepticism and distrust.<sup>41</sup>

Hong Kong serves as an interesting context outside of the often-studied Western countries to examine how vaccination decision hinges on societal factors when perceived threat and public trust are low. Although we expected the five 'Cs' to remain robust factors of vaccine hesitancy, based on the socioecological framework of vaccine trust,<sup>18,43</sup> we hypothesised that interpersonal influences as well as attitudes to public institutions are also crucial determinants.

## Methods

We conducted an online survey in traditional Chinese with Hong Kong residents aged  $\geq 18$  years through a panel from the Public Opinion Research Institute, an independent polling agency, between 25 and 28 June 2021 and collected 4386 responses. Respondents provided their e-consent before beginning the survey and were not compensated for their participation. Responses

completed under 5 min were excluded on suspicion about data quality and attention to the question items.

First, to measure vaccine hesitancy, respondents were asked, 'Have you been vaccinated? (Yes/Scheduled/No)'. Those who answered 'No' were further asked, 'Are you planning to get vaccinated in the next few months? (Yes/Maybe/No)'. This allowed us to categorise respondents into *acceptant*, *hesitant* and *resistant*. As vaccine hesitancy can be represented on a spectrum from complete refusal to temporary undecidedness,<sup>1</sup> we distinguished the group who were undecided (i.e. *hesitant*) from those who expressed refusal (i.e. *resistant*). The former's vaccination intention could be more amenable to change than the latter and render them more realistic policy targets. Hence, our analysis sought to distinguish those who accepted vaccination (i.e. vaccinated, scheduled or indicated a positive intention; i.e. *acceptant*) and the *resistant* from the *hesitant*.

The survey then asked attitudinal questions to construct the independent variables, including threat appraisal towards COVID-19 and towards the vaccine based on the 5C model,<sup>12</sup> trust towards public institutions (Hong Kong SAR government, the public health departments and public health experts),<sup>19,20</sup> confidence towards government's containment measures and whether getting vaccinated is an act of supporting the government. The threat appraisal items were adapted from the Health Belief Model and were used in our previous study.<sup>42</sup> The items for the five 'Cs' (except complacency) were adapted from Betsch et al.,<sup>12</sup> with additional items constructed as per the COVID-19 containment policies at the time of data collection. To measure interpersonal influences, respondents were asked to estimate, on two self-created items, the proportion of their family and friends that had been vaccinated. Demographics, media usage and trust towards their family, friends and the community were also collected as control variables. As the study was conducted after the enactment of the National Security Law (NSL), under the sensitive political environment, we invited respondents to identify themselves in one of the following categories for their political orientation: non-pro-establishment, pro-establishment, centrist, others, unaffiliated to or unknown of any political orientation. At the point of observation, there is no conclusive remark on whether the NSL could mobilise Hong Kong citizens to further commit to their political identity or if they feel the need to withdraw from politics in fear of their safety and well-being.<sup>43</sup> We used non-conservative as a reference group and grouped other categories as politically conservative (see [Tables 1 and 2](#) for the items).

We first performed univariate analyses by one-way analyses of variance with Tukey's adjustment to identify significant predictors, followed by multinomial logistic regression using the statistically significant predictors to predict vaccine hesitancy with *hesitant* as the reference category. Among the 4386 respondents, 2753 provided complete responses for the analysis. Following the simulation study of Pepinsky,<sup>44</sup> we opted for listwise deletion over multiple imputation, as the data have been identified as missing-not-at-random and multiple imputation may produce more biased results than listwise deletion. The data have been weighted with raking by the age group and gender of the respondents according to the Hong Kong census. This study was approved by the Human Research Ethics Committee of the University of Hong Kong (EA2003003).

## Results

Our sample had a vaccination rate of 34.6% ( $n = 952$ ), whereas 4.6% ( $n = 125$ ) had scheduled their vaccination and 60.9% ( $n = 1675$ ) had not been vaccinated. The vaccination rate was very similar to the official estimate of 33.0% population coverage rate

**Table 1**  
Items measuring factors of vaccine hesitancy.

Variable	Items	Cronbach alphas
Confidence Range = 1 (strongly disagree) to 7 (strongly agree)	<ol style="list-style-type: none"> <li>1. The COVID-19 vaccine may have physical side-effects and I don't want risk my health (R)</li> <li>2. I believe that the COVID-19 vaccine can reduce my chance of infection or the severity of the disease in case of an infection.</li> <li>3. I believe that I can travel abroad earlier after vaccination.</li> <li>4. I am confident about the safety of COVID-19 vaccine.*</li> <li>5. I worry about the short protection duration of the COVID-19 vaccine</li> <li>6. I am worried that if I don't get vaccinated, I will need to practice social distancing for an extended period of time.</li> <li>7. I wish others to know that I have been vaccinated as I want to be seen as COVID-free.</li> </ol>	0.75
Collective good Range = 1 (strongly disagree) to 7 (strongly agree)	<ol style="list-style-type: none"> <li>1. I believe that COVID-19 vaccine can protect my loved ones and the vulnerable groups in the community.</li> <li>2. Persuading others to get vaccinated can enhance collective good.</li> </ol>	0.77
Complacency Range = 1 (strongly disagree) to 7 (strongly agree)	<ol style="list-style-type: none"> <li>1. As an infectious disease, COVID-19 is not severe enough to warrant vaccination. *</li> </ol>	N/A
Constraints Range = 1 (strongly disagree) to 7 (strongly agree)	<ol style="list-style-type: none"> <li>1. My everyday stress and schedules made me reluctant to get vaccinated.*</li> </ol>	N/A
Calculation Range = 1 (strongly disagree) to 7 (strongly agree)	<ol style="list-style-type: none"> <li>1. When I decide whether to get vaccinated, I will consider the risks and the benefits and made the best decision out of such consideration. *</li> </ol>	N/A
Threat appraisal of COVID-19 Range = 1 (not at all) to 10 (very much)	<ol style="list-style-type: none"> <li>1. How severe do you think the current outbreak is?</li> <li>2. How likely do you think you will be infected with COVID-19?</li> </ol>	0.63
Institutional trust Range = 1 (not at all) to 7 (very much)	<ol style="list-style-type: none"> <li>1. To what extent do you trust the HKSAR government?</li> <li>2. To what extent do you trust the public health departments?</li> <li>3. To what extent do you trust the public health experts?</li> </ol>	0.71
Confidence in government policy Range = 1 (not at all) to 10 (very much)	<ol style="list-style-type: none"> <li>1. To what extent are you confident that the existing pandemic control policies of the government can prevent you from COVID-19 infection?</li> </ol>	
Vaccination as support to government Range = 1 (strongly disagree) to 7 (strongly agree)	<ol style="list-style-type: none"> <li>1. Getting vaccinated can be seen as supporting the government's policy.</li> </ol>	
Extent of family vaccinated Range = 1 (none) to 4 (all)	<ol style="list-style-type: none"> <li>1. What is the proportion of your family members who have been vaccinated with COVID-19 vaccine?</li> </ol>	
Extent of friends vaccinated Range = 1 (none) to 4 (all)	<ol style="list-style-type: none"> <li>1. What is the proportion of your friends who have been vaccinated with COVID-19 vaccine?</li> </ol>	
Interpersonal trust Range = 1 (not at all) to 7 (very much)	<ol style="list-style-type: none"> <li>1. To what extent do you trust your family members?</li> <li>2. To what extent do you trust your friends?</li> <li>3. To what extent do you trust your neighbours?</li> <li>4. To what extent do you trust a stranger?</li> </ol>	0.69
Reliance on traditional media Range = 1 (not at all) to 7 (very much)	<ol style="list-style-type: none"> <li>1. How often do you rely on newspapers for news-related information?</li> <li>2. How often do you rely on television for news-related information?</li> </ol>	0.51
Reliance on online media Range = 1 (not at all) to 7 (very much)	<ol style="list-style-type: none"> <li>1. How often do you rely on online news media for news-related information?</li> <li>2. How often do you rely on social media for news-related information?</li> </ol>	0.59

Note. Asterisk items were adapted from a study by Betsch et al.<sup>12</sup>

(excluding those aged <18 years) as on 28 June 2021, supporting the representativeness of our data regarding vaccination status. Among the 1675 respondents who had not vaccinated, only 6.6% (111/1675) were planning to do so (Yes). Meanwhile, 35.7% (598/1675) were considering getting vaccinated (Maybe), and 57.4% (967/1675) were not planning to do so (No). Hence, the three groups – *acceptant*, *hesitant*, and *resistant* – constituted 43.2% (1188/2753), 21.7% 598/2573) and 35.1% (967/2573) of the sample, respectively.

Sample characteristics are presented in Table 2. About half were male, with 40–44 years being the median age group. About one-third of the sample had at least one health condition, and 46.4% were living with a vulnerable individual. About 10% were in an

occupation that requires regular COVID-19 testing, and 66.2% identified themselves as non-pro-establishment.

Univariate comparisons across the three groups (*acceptant*, *hesitant* and *resistant*) are presented in Table 3. The three groups were significantly different on all 5Cs, except calculation, which indicated a ceiling effect (mean scores over six out of seven). *Acceptant* was highest on confidence and collective good and lowest on complacency and constraints. The three groups were also significantly different in institutional trust. *Resistant* was most distrustful of public institutions and were most likely to see vaccination as supportive of the government.

*Acceptant* indicated more vaccinated family members and friends than *hesitant* and *resistant*. The proportions of respondents

**Table 2**  
Sample characteristics (N = 2753).

Variable	Category	Valid, n (%) / M (SD)
Gender	Female	1352 (49.1%)
	Male	1401 (50.9%)
Age group	18–25	213 (7.7%)
	25–29	217 (7.9%)
	30–34	252 (9.2%)
	35–39	286 (10.4%)
	40–44	256 (9.3%)
	45–49	252 (9.2%)
	50–54	232 (8.4%)
	55–59	268 (9.7%)
	60–64	225 (8.2%)
	65+	551 (20.0%)
Education	Primary or less	5 (0.2%)
	Junior secondary	69 (2.5%)
	Senior secondary	464 (14.5%)
	Diploma	400 (14.5%)
	Undergraduate or more	1813 (65.9%)
Socio-economic status	Lower	8 (0.3%)
	Lower middle	112 (4.1%)
	Middle	1080 (39.2%)
	Upper-middle	1124 (40.8%)
	Upper	428 (15.5%)
Health condition vulnerable to a severe course of COVID-19 infection (pregnancy, cardiovascular diseases, high blood pressure, diabetes, chronic respiratory diseases, cancer and others)	Present	860 (31.3%)
	Absent	1892 (68.7%)
Co-residence with physically vulnerable individual (a toddler, child, woman in pregnancy, older adult, person with physical disabilities or chronic illnesses and others)	Yes	1277 (46.4%)
	No	1476 (53.6%)
Occupation that requires regular COVID-19 testing (such as workers of residential care homes for elderly/persons with disabilities, nursing homes, day care units, Hong Kong International Airport, quarantine sites, hotels, catering industry, construction sites, swimming pools and beaches, tour groups)	Yes	276 (10.0%)
	No	2477 (90.0%)
Political orientation	Non-conservative	1821 (66.2%)
	Conservative	931 (33.8%)

indicating more than half of their family or friends being vaccinated were 34.6% and 12.5%, respectively, for *acceptant*, but only 1.3% and 0.7% for *resistant*. A total of 16.8% of *acceptant* and 57.8% of *resistant* indicated none of their family members have been vaccinated. The estimation for friends' vaccination tended to be more conservative and clustered around 'Quite a bit' (79.3% [*resistant*] to 90.3% [*hesitant*]). *Acceptant* reported highest reliance on traditional media

(television and newspaper), whereas *resistant* indicated highest reliance on online information. Interpersonal trust was similar across the three groups. All groups had low threat appraisal (less than 3 out of 10).

All predictors were used in the multinomial logistic models together with the demographic variables, except calculation, interpersonal trust and threat appraisal, which did not vary

**Table 3**  
Comparisons of key variables by vaccination intention (N = 2753).

Variable	(a) Acceptant (n = 1188), mean (SD)	(b) Hesitant (n = 598), mean (SD)	(c) Resistant (n = 967), mean (SD)	Omnibus P	(a) vs (b) P	(b) vs (c) P	(a) vs (c) P
Confidence	4.20 (0.98)	3.27 (0.78)	2.71 (0.81)	<0.001	<0.001	<0.001	<0.001
Collective good	4.86 (1.52)	3.66 (1.39)	2.77 (1.46)	<0.001	<0.001	<0.001	<0.001
Complacency	2.78 (1.66)	3.53 (1.47)	3.92 (1.75)	<0.001	<0.001	<0.001	<0.001
Constraints	2.73 (1.53)	3.60 (1.65)	3.48 (1.90)	<0.001	<0.001	0.397	<0.001
Calculation	6.08 (1.05)	6.07 (0.96)	6.10 (1.23)	0.826	0.988	0.843	0.873
Threat appraisal of COVID-19	2.90 (1.45)	2.92 (1.37)	2.82 (1.58)	0.386	0.975	0.463	0.469
Institutional trust	2.74 (1.31)	2.34 (1.00)	1.97 (0.88)	<0.001	<0.001	<0.001	<0.001
Confidence in government policy	2.64 (2.10)	2.12 (1.57)	1.86 (1.45)	<0.001	<0.001	0.013	<0.001
Vaccination as support to government	2.94 (1.86)	3.95 (1.95)	4.22 (2.12)	<0.001	<0.001	0.023	<0.001
Extent of family vaccinated	2.32 (0.92)	1.59 (0.59)	1.44 (0.53)	<0.001	<0.001	<0.001	<0.001
Extent of friends vaccinated	2.09 (0.40)	1.94 (0.31)	1.81 (0.42)	<0.001	<0.001	<0.001	<0.001
Interpersonal trust	4.44 (0.87)	4.33 (0.85)	4.27 (0.90)	<0.001	0.027	0.400	<0.001
Reliance on traditional media	4.04 (1.72)	3.93 (1.59)	3.84 (1.70)	0.021	0.389	0.549	0.015
Reliance on online media	5.85 (1.11)	5.93 (0.97)	6.04 (1.06)	<0.001	0.301	0.112	<0.001

Note. The omnibus P values were determined by analysis of variance. The P values of the paired comparisons were determined by post-hoc analyses with Tukey's adjustment.

**Table 4**  
Results of multivariate multinomial logistic regressions (*n* = 2753).

Independent variables	Acceptant (Ref = hesitant) aOR (95% CI)	Resistant (Ref = hesitant) aOR (95% CI)
Sex (Ref = female)	0.83 (0.65–1.05)	1.44 (1.15–1.81)**
Age group	0.95 (0.90–1.00)*	1.04 (1.00–1.09)
Education	1.13 (0.97–1.32)	0.87 (0.76–1.00)
Socio-economic status	0.86 (0.72–1.02)	0.96 (0.82–1.12)
Health condition vulnerable to a severe course of COVID-19 infection (pregnancy, cardiovascular diseases, high blood pressure, diabetes, chronic respiratory diseases, cancer and others) (Ref = Nil)	0.61 (0.46–0.80) ***	1.50 (1.17–1.93)**
Co-residence with physically vulnerable individual (a toddler, child, woman in pregnancy, older adult, and person with physical disabilities or chronic illnesses and others) (Ref = Nil)	1.26 (0.99–1.60)	1.01 (0.81–1.27)
Occupation that requires testing (Ref = Nil)	1.78 (1.20–2.65)**	0.87 (0.59–1.28)
Political orientation (Ref = conservative)	0.92 (0.71–1.19)	1.08 (0.85–1.37)
Confidence	2.67 (2.21–3.23)***	0.54 (0.45–0.64)***
Collective good	1.06 (0.95–1.17)	0.86 (0.79–0.95)**
Complacency	0.91 (0.84–0.98)*	1.07 (1.00–1.15)*
Constraints	0.90 (0.84–0.97)**	0.92 (0.86–0.98)*
Trust in government	0.91 (0.80–1.03)	0.85 (0.74–0.96)*
Confidence in government COVID containment policy	0.93 (0.85–1.00)	1.07 (0.98–1.15)
Vaccination as support for government	0.80 (0.75–0.85)***	1.05 (1.00–1.11)
Extent of family vaccinated	2.68 (2.23–3.23)***	0.71 (0.59–0.86)**
Extent of friends vaccinated	1.40 (0.96–2.04)	0.53 (0.38–0.73)***
Traditional information source	0.94 (0.87–1.08)	1.02 (0.95–1.10)
Online information source	0.96 (0.86–1.08)	1.07 (0.96–1.19)

Note. The first column refers to the comparison between *acceptant* and *hesitant*; the second column the comparison between *resistant* and *hesitant*.

aOR, adjusted exponentiated odds ratios; CI, confidence interval.

\**P* < 0.05; \*\**P* < 0.01; \*\*\**P* < 0.001.

significantly across the groups. Table 4 presents the results of the multinomial regressions (Akaike information criterion = 4038.5; Bayesian information criterion = 4275.4;  $-2\text{LogLikelihood} = 3958.5$ ; Likelihood test:  $\chi^2(38) = 1887.5, P < 0.001$ ).

First, the 5C model only partially explained vaccination decisions. Respondents who had confidence in the vaccines were more likely to be acceptant and less likely to be resistant. Those who were more complacent (i.e. perception that COVID-19 is not serious enough for warranting vaccination) were more likely to be resistant and less likely to be acceptant. However, collective good only had a partial positive effect. Although respondents who thought vaccination promotes the collective good were less likely to resist the vaccine (compared with *hesitant*), they were not statistically more likely to accept it (also compared with *hesitant*). Meanwhile, although constraints were statistically significant, its effect was not linear – *hesitant* tended to report facing more constraints than *acceptant* and *resistant*.

Second, trusting public institutions made people less resistant to the vaccine, but it did not make them more acceptant. A partial effect was also found with perceiving vaccination as supportive of the government. The construct divided respondents who accepted the vaccine from those who did not, but it was not helpful in further dividing those who were hesitant from the resistant respondents. No significant effect, meanwhile, was shown in respondents' confidence in the government's containment policy.

Third, vaccination among family members had a particularly important impact. Not only did it make respondents less resistant to the vaccine but also significantly enhanced their likelihood of accepting it. However, there was only a partial effect in vaccination among friends. Respondents who had more friends who were vaccinated were less likely to resist, but they were not necessarily more likely to accept the vaccine.

Finally, male respondents were more likely to be *resistant* than *hesitant*, whereas younger respondents were more likely to be *acceptant* than *hesitant*. No independent significant effect was found with education, socio-economic status, sources of information and political orientation. Respondents who were required to have regular testing because of their occupation were more acceptant than hesitant. However, the presence of a health condition rendered respondents not only hesitant (compared with *acceptant*) but also resistant (compared with *hesitant*) to the vaccine.

### Discussion and conclusion

This study investigated how individual and societal factors shape vaccination hesitancy in Hong Kong – a context where there has been both low incidence of COVID-19 due to the government's zero tolerance policy,<sup>45–49</sup> and low trust in the government after the year-long social unrest since the mid-2019.<sup>39–41</sup> While confidence and complacency had significant effects similar to the findings of extant studies,<sup>13,14,16</sup> the other 3 'Cs' – collective good, constraints and calculation – had either minimal or partial effects. Our findings are interesting in several ways. First, Hong Kong's low COVID-19 incidence may have made 'protecting others' a less compelling reason for getting vaccinated. Although collective good makes people less resistant to the vaccine, it does not lead them to accept it. Second, *resistant* and *acceptant* reported fewer constraints than *hesitant*. Hence, perceived barriers may only matter when people are juggling with getting vaccinated or not, rather than swaying them towards a positive or negative stance. Third, calculation was consistently high across all three groups, indicating that Hong Kong citizens carefully weigh the cost against the benefits of vaccination regardless of their stances. In a local study, which examined parental decision on COVID-19 vaccination for their



school-aged children, only confidence emerged as a significant predictor.<sup>50</sup> Parental decisions about COVID-19 vaccination are often heavily impacted by concerns over safety and side-effects, especially the long-term ones.<sup>51</sup> The contrasting findings of this study with ours call for investigation on the potentially differentiated cognitive processes behind a vaccination decision for oneself vs one for a vulnerable relative.

Beyond the 5C model,<sup>12</sup> our results show that societal factors are essential in explaining vaccine hesitancy in Hong Kong. On the one hand, decisions are evidently shaped by attitudes towards public institutions in this low public trust environment.<sup>39–41</sup> This echoes with a recent study from Korea, which shows an inverse relationship between vaccine hesitancy and trust in government's COVID-19 countermeasures.<sup>52</sup> Their measurement of trust was competence based, which is slightly different from ours. Nonetheless, these findings make intuitive sense because trusting public institutions can reduce people's misgivings about the consequences of getting the COVID-19 vaccines under the concerns over them being newly developed, entailing new technologies, and bearing unknown side-effects.<sup>32</sup> However, trusting public institutions does not necessarily entail acceptance – it only makes people more likely to consider it. We found that what differentiates people who accept from those who hesitate or resist is an alternative measure of trust in the government – the extent to which people perceive vaccination as an act of supporting the government. This measure captures a more relational dimension of trust, with the implication that people may not want to be publicly seen as supporting the government when public trust in the government remains low.<sup>39–41</sup> Altogether, our findings reveal that it is not institutional trust or political orientation that makes people accept the vaccine; instead, it is the perception that vaccination is a socially – or politically – sensitive behaviour that matters. Although extant studies have shown political partisanship may affect the intention to receive COVID-19 vaccination,<sup>33–35,52,53</sup> we urge future studies to account for the sociopolitical meaning of vaccination, especially in highly polarised states. This study also offers a socioecological perspective for studying the antivaccine movement or how people withdraw from vaccination campaign due to bundling of vaccination and political identity. In principle, strategies such as borrowing trust from trusted experts to improve the trustworthiness of the vaccination programme, promoting vaccination when the perceived risk is elevating or offering realistic incentives to reward vaccination (e.g. relaxing social distancing for vaccinated individuals) may work. However, the effectiveness of these strategies may be sensitive to the social context, and the empirical findings regarding why they work in one context but not in the other remain scant and inconclusive.<sup>54</sup>

Furthermore, family is an important medium in which vaccination decisions are transmitted in Hong Kong. Yet, friends are weak influencers. Our findings indicate that the socialisation of vaccination decisions seldom goes beyond the family, which undermines the networked effect of vaccination. An important point to note here, however, is that our findings merely point to correlation, rather than causation. While it could be friends and family that influence individuals' vaccination decisions, it could also be the other way around. Thus, we call for more family-friendly arrangements for vaccination, such as allowing a family member to register and attend the vaccination session together with a vulnerable relative.

In addition to the data being cross-sectional and therefore unable to infer the direction of causality, some items were constructed in response to the fast-changing and specific context of COVID-19 in Hong Kong rather than based upon standardised instruments. We acknowledge the limitation of this approach in psychometric terms, yet this would have safeguarded the contextual relevance and

validity of our findings. The sample was recruited from a panel of the polling company, and hence, a non-probability one. Representation by individuals who are less educated, unable to access the internet or have difficulties reading traditional Chinese was constrained. As foreign workers and foreign domestic helpers were excluded as the survey was conducted in traditional Chinese, our vaccination rates might be slightly lower than the actual number. As the survey was self-reported, there was no way to verify the accuracy of respondents' vaccination status and whether they got vaccinated eventually. Finally, we witnessed a high incompleteness rate, especially among male, older and less educated respondents, similar to other surveys.<sup>55,56</sup> However, the political orientation of those who completed the survey and those who dropped out was not significantly different. Hence, their attrition is unlikely due to political stances and should not bias our findings.

To conclude, the case of Hong Kong reveals that vaccination for COVID-19 is as much a *social* decision as a *personal* decision. COVID-19 vaccination decisions are shaped by societal factors, namely, interpersonal influences and institutional trust. Although most policies to boost vaccination uptake pre-COVID-19 relied on information provision, education, incentives, reminders and quasi-mandatory schemes,<sup>57</sup> policymakers – especially those in a low-trust, low-incidence context – should examine the interpersonal and political determinants and devise solutions accordingly to render COVID-19 vaccination socially desirable.

## Author statements

### Ethical approval

This study was approved by the Human Research Ethics Committee of the University of Hong Kong (EA2003003).

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### Competing interests

None declared.

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## Review Paper

# Vaccine hesitancy in American healthcare workers during the COVID-19 vaccine roll out: an integrative review



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## ABSTRACT

*Objective:* The purpose of this integrative review is to examine the literature on vaccine hesitancy among American healthcare workers during the COVID-19 vaccine rollout.

*Methods:* A review of quantitative literature on acceptance, intention, refusal, or hesitation to accept the COVID-19 vaccine was conducted, searching in PubMed, Cumulative Index for Nursing and Allied Health Literature, PsycINFO, and Web of Science. Because of the immediacy of the topic, research letters were included in addition to articles. The 18 publications were appraised for quality using the Critical Appraisal Checklist for Cross-Sectional Studies by the Center for Evidence-Based Management.

*Results:* Estimates of vaccine hesitancy among healthcare workers were similar to the general population. The literature indicates demographic characteristics associated with vaccine hesitancy, including being younger, female, Black, Hispanic, or Latinx. However, examination of the demographic data also points to gaps in the understanding and implications of those characteristics. The newness or perceived rush of vaccine development and implementation were the most cited sources for hesitancy.

*Conclusion:* The studies in this review give clear areas of need for translational research on dissemination and implementation relating to the correlational data, including in areas of comorbid, diasporic, and reproductive health concerns. However, with the gravity of the pandemic and quick arrival of the COVID-19 vaccine happening in the midst of an infodemic, adjunctive interventions could be warranted to combat hesitancy.

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## Introduction

For over 2 years, healthcare workers (HCWs) around the globe have been providing care and services during the COVID-19 pandemic, putting themselves at an increased risk for contracting the potentially deadly disease.<sup>1–5</sup> In the same month that the battle against COVID-19 began, the US Department of Health and Human Services issued a statement about accelerating the development and production of vaccines under Operation Warp Speed (OWS).<sup>6</sup> OWS had the distinct goal of speed without sacrificing safety. Development was synergized by large funding streams, previous middle east respiratory syndrome (MERS), severe acute respiratory syndrome (SARS), and RNA vaccine research, the ability of researchers to run multiple trials, and advances in manufacturing.<sup>7</sup> The goal of OWS was subsequently attained within the first year

of the pandemic by two vaccines granted emergency use authorization (EUA) by the Food and Drug Administration on December 11, 2020.<sup>8–11</sup>

Eight days before the EUAs, the centers for disease control and prevention (CDC's) Advisory Committee on Immunization Practices recommended that HCWs be among the first Americans offered vaccination under the EUAs, citing "early protection of healthcare personnel is critical."<sup>12</sup> Approximately 17.5 million Americans belong to this category<sup>13</sup> and have become subject to vaccination mandates.

General population hesitancy regarding the COVID-19 vaccine has been correlated with being female, Black, and younger. Additional correlates could include lower educational attainment, rural or geographic residence, prior vaccination hesitancy, and lower perceived risk of COVID-19.<sup>14–19</sup> Furthermore, a perceived rush over vaccine development and approval, as well as concerns over safety and efficacy has plagued public health campaigns.<sup>14,16,18,19</sup> Saliiently, the spread of mis- and dis-information, culminating in an infodemic, has underscored the COVID-19 pandemic and vaccine

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development.<sup>20,21</sup> America has seen a relatively large distribution of misleading or false information surrounds the pandemic and vaccine rollout, and more than one-third of mis- or dis-information regarding the COVID-19 vaccine was related to vaccine development during the year of the rollout.<sup>22,23</sup> The unprecedented nature of the virus and subsequent vaccine development, as well as the nature of the infodemic in which it has been unfolding, differentiates COVID-19 vaccine hesitancy from vaccine hesitancy around long-standing vaccines. Yet, despite the differences in context, vaccines remain the most effective way to curb the spread of infectious disease. With so many Americans employed in the healthcare sector, implications for COVID-19 spread among HCWs, their patients, and communities at large are substantial. Thus, the purpose of this integrative review is to synthesize and examine the quantitative literature specific to HCWs' hesitancy surrounding the rollout of the COVID-19 vaccine.

## Methods

This review was guided by Whittmore and Knafel (2005) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.<sup>24,25</sup> Critical appraisal was conducted with the Critical Appraisal Checklist for Cross-Sectional Studies<sup>26</sup> (Table 1).

The literature search was conducted in July 2021 using the Cumulative Index for Nursing and Allied Health Literature via EBSCO, Medline via PubMed, Web of Science, and PsycINFO. Databases were searched for "COVID-19 vaccine," and alternate terms of "Coronavirus" and "Sars-CoV-2," paired with keywords such as "acceptance," "intention," "hesitancy," "attitude," "uptake," "confidence," and "refusal." Relevant search terms for the population of interest, "healthcare workers," included "health personnel," "healthcare provider," "health professional," and "nurse." Truncation was used when possible.

Inclusion criteria were left purposely broad to include all types of HCWs and facilities. Data collection conducted on American HCWs in or after 2020 was the primary inclusion criteria based on the United States' unique social and healthcare landscape. The American pandemic response, which included OWS and timely access to vaccines, focused on HCWs as a primary class of vaccine recipients. Letters were included based on the immediacy of the topic, offering comprehensive coverage as data was emergent. A total of 1533 records were obtained. After duplicate removal, 922 citations were screened, 28 went to full-text review, and 18 are included in this review (Fig. 1).

## Results

Of the 18 studies, 11 were peer-reviewed articles<sup>27–37</sup> and seven were research letters.<sup>38–44</sup> All 18 published data from cross-sectional surveys collected over short periods on participants gained from non-probability sampling frames. All studies gave a snapshot of vaccination acceptance or intention and refusal or hesitancy among their sample. Correlational trends were most often given as odds ratios. Most asked additional questions, but less than half the publications reported using trialed or validated questionnaires. Surveys included reasons for hesitancy and safety or efficacy perceptions.

The largest sample size was 16,292 participants,<sup>42</sup> the smallest 81,<sup>27</sup> and the median 1600.<sup>40,44</sup> The shortest study was 3 days in length,<sup>37</sup> with most completed in 2 weeks to a month. An exception was Halbrook et al.,<sup>31</sup> with data collected at three time points from September 2020 to February 2021. Of the studies reporting response rates, the lowest was 10%,<sup>28</sup> and the highest was 82%.<sup>29</sup> The oldest data collection was done in August 2020,<sup>34</sup> and seven

collected data in December of 2021, the month of the EAUs.<sup>29–32,35,40,42</sup> (Table 2).

The publications included a total sample population of 62,728 HCWs. Two articles focused on specific occupational roles of medical doctors<sup>27</sup> or nurses.<sup>30</sup> Apart from those exceptions, occupational totals were reported too diversely to synthesize effectively. One study was conducted in long-term care facility,<sup>37</sup> and two studies were conducted in community-based care settings.<sup>29,43</sup> The remaining 16 were conducted entirely in, or included, hospital settings. Eleven studies were multisite,<sup>29–31,33,34,36–40,44</sup> with three being multistate.<sup>33,36,44</sup> More than half of the study populations came from the Northeast; however, all regions of the United States were represented.

## Sample demographics

Of the studies that reported on gender ( $N = 46,279$ ), 75.8% of those sampled were female. Three studies<sup>27,42,43</sup> do not include any information on race ( $N = 16,530$ ; 81, 16,292, and 157, respectively). For the total sample that reported race ( $N = 46,198$ ), approximately 65.2% were White, which may be further underreported because Kociolek et al.<sup>41</sup> queried race as Black or non-Black, which excludes 3866 participants. Similarly, Pacella-LaBarbara et al.<sup>33</sup> classify race as White and non-White; however, the sample size was significantly smaller ( $N = 475$ ), and the population was identified as 95% White. Hispanic or Latinx participation was either included as a classification within race or classified as a separate category of ethnicity. Five publications<sup>30,31,33,35,38</sup> did not report on Hispanic or Latinx participation at all ( $N = 10,084$ ). Of the studies reporting ethnicity as a category within race, the overall samples were 1.8% Hispanic or Latinx.<sup>28,29,32,40,44</sup> Of those separating out ethnicity, Hispanic or Latinx identity was reported for 25.8% of the sampled population ( $N = 19,886$ ); however, approximately 41% of the sample was not reported,<sup>30,31,33–37,39,41</sup> making accurate assessment impossible.

Age was reported in a variety of ways, except for the two letters in which age was not reported.<sup>42,43</sup> Two articles<sup>33,35</sup> reported the mean age of participants as 40 and 42.5, respectively. Most participants' age ( $N = 26,357$ ) was reported by two articles<sup>32,37</sup> and two letters<sup>40,41</sup> using a cutoff of 40 years. Participants were almost evenly distributed, with 51% being aged <40 years, 45.3% being >40 years, and 3.7% of data were unreported (Table 3).

## Vaccination data

Overall, 68.8% ( $N = 42,284$ ) of the sample population indicated they had or would receive a COVID-19 vaccine. Almost half the studies<sup>28–30,33,34,36,37,39</sup> included an option for future vaccination intention, ranging from specific timeframes (e.g. within 30 days) to simply "sometime in the future" or to "wait and see." Acceptance or immediate intention ranged in studies from 33% to 95%, with a median of approximately 63%. Those that either reported they would or did refuse or, if given the option, were unsure they would get the vaccine, was 31.2% ( $N = 19,199$ ). If separated out, 18.8% refused, and 12.4% were unsure. If separating out positive intention, 15% of those given the option reported wanting to wait for vaccination. The number of missing or not reported answers for the total sample was 1245 or approximately 2%.

Data stratified by EUA date exhibit temporal variations in intention (Fig. 2). Of studies with data collection before the EUA month of December 2020 ( $N = 16,467$ ), 77.3% of the sample report positive intention, 19.1% refusing, and 3.6% of the data are not reported. Of the data collected during the month of the EUA ( $N = 36,902$ ), 59.9% reported positive intention, 37.7% were unsure or refusing, and 2.4% of the data were unreported. For the data

**Table 1**  
Center for evidence-based management: critical appraisal checklist for cross-sectional study.

Appraisal questions	1. Did the study address a clearly focused question/issue?	2. Is the research method (study design) appropriate for answering the research question?	3. Is the method of selection of the subjects (employees, teams, divisions, organizations) clearly described?	4. Could the way the sample was obtained introduce (selection) bias?	5. Was the sample of subjects representative with regard to the population to which the findings will be referred?	6. Was the sample size based on pre-study considerations of statistical power?	7. Was a satisfactory response rate achieved?	8. Are the measurements (questionnaires) likely to be valid and reliable?	9. Was the statistical significance assessed?	10. Are confidence intervals given for the main results?	11. Could there be confounding factors that haven't been accounted for?
Abohelwa <sup>27</sup>	Yes	Can't Tell	Can't Tell	Yes	Can't Tell	No	0.27	Can't Tell	No	No	Yes
Ciardi <sup>28</sup>	Yes	Yes	No	Yes	Can't Tell	No	0.1	Yes	Yes	Yes (for some)	Yes
Famuyiro <sup>29</sup>	Yes	Yes	No	Yes	Can't Tell	No	0.82	Yes	Yes	Yes (for some)	Yes
Fotenot <sup>30</sup>	Yes	Yes	Yes	Can't Tell	Yes	No	0.21	Yes	Yes	Yes	Yes
Halbrook <sup>31</sup>	Yes	Yes	Can't Tell	Can't Tell	Can't Tell	No	NR	Can't Tell	Yes	Yes	Yes
Kuter <sup>32</sup>	Yes	Yes	Yes	Can't Tell	Can't Tell	No	0.345	Can't Tell	Yes	Yes	Yes
Pacella <sup>33</sup>	Yes	Yes	Can't Tell	Yes	Can't Tell	No	NR	Can't Tell	Yes	Yes	Yes
Parente <sup>34</sup>	Yes	Yes	Yes	Can't Tell	Yes	No	0.18	Can't Tell	Yes	Yes	Yes
Shaw <sup>35</sup>	Yes	Yes	Yes	Yes	Can't Tell	No	0.55	Yes	Yes	No	Yes
Shekhar <sup>36</sup>	Yes	Yes	Yes	Yes	Can't Tell	No	NR	Can't Tell	Yes	No	Yes
Unroe <sup>37</sup>	Yes	Yes	Yes	Can't Tell	Yes	No	0.33	Can't Tell	Yes	Yes (for some)	Yes
<b>Letters</b>											
Fossen <sup>38</sup>	Yes	Yes	Yes	No	—	—	—	Yes	Yes	Yes	Yes
Gadoth <sup>39</sup>	Yes	Yes	Can't Tell	Yes	Can't Tell	No	0.57	Can't Tell	No	Yes	Yes
Grumbach <sup>40</sup>	Yes	Yes	Can't Tell	Can't Tell	Yes	No	NR	Can't Tell	Yes	Yes	Yes
Kociolek <sup>41</sup>	Yes	Yes	Yes	Yes	Can't Tell	No	0.63	Can't Tell	Yes	Yes	Yes
Meyer <sup>42</sup>	Yes	Yes	Can't Tell	Can't Tell	Yes	No	0.685	Can't Tell	Yes	Yes	Yes
Pamplona <sup>43</sup>	Yes	Yes	Yes	No	—	—	—	Yes	No	No	Yes
Schrading <sup>44</sup>	Yes	Yes	Can't Tell	Yes	Can't Tell	No	NR	Can't Tell	No	No	Yes

Note. NR = not reported.



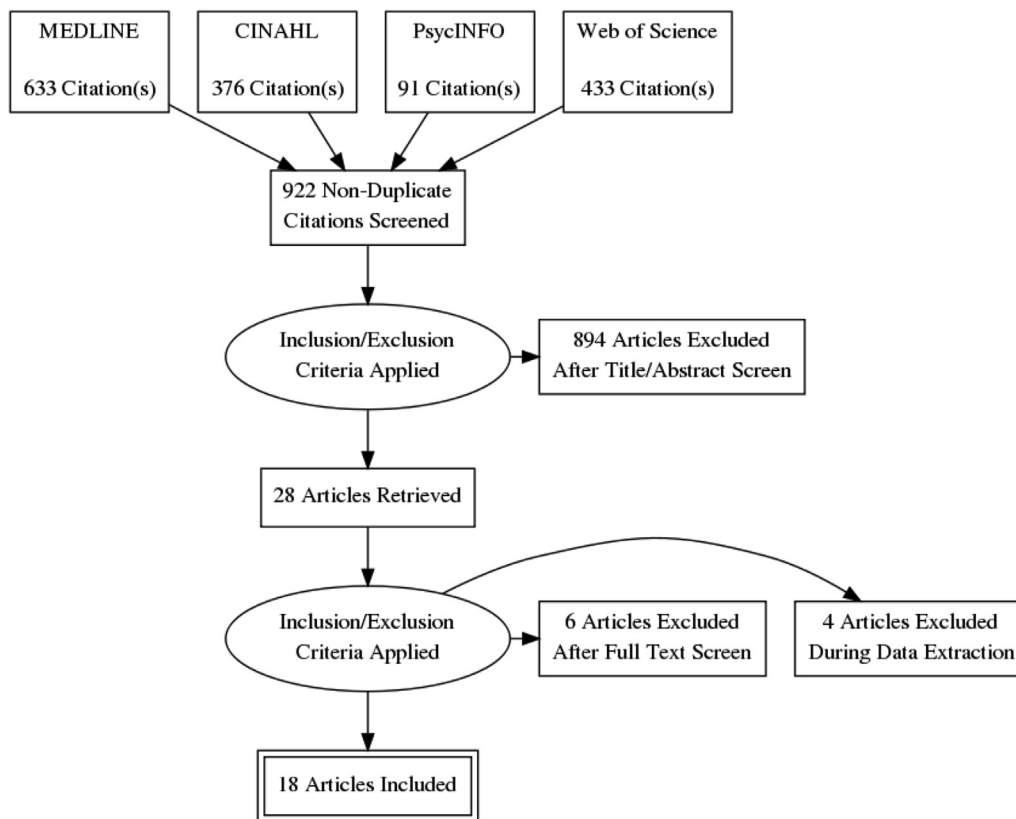


Fig. 1. PRISMA diagram of article selection.

collected after the EUA month, (N = 11,075) 73.6% reported vaccination, 1.2% had positive intentions for future vaccination, 15.7% refused, and 3.9% were unsure, with 5.6% of the sample was unreported. Data stratified by EUA date may indicate positive intention was at its lowest, both in the crude and adjusted ratios, during EUA passages in December.

Correlational findings

Most correlational findings associated sociodemographic characteristics, with vaccine hesitancy, namely, gender, race/ethnicity, age, and education, whereas other factors, such as safety, perceived risk, and prior vaccination, were also explored. Eleven studies compared gender with vaccine hesitancy and found that females had greater hesitancy than males, with two studies also referencing lower intent than non-binary counterparts. However, Halbrook et al. noted that while females had higher levels of hesitation, they actually had statistically significantly higher rates of vaccination acceptance than their male counterparts.

Thirteen studies reported on the correlations of hesitancy with race and/or ethnicity. The majority cited more hesitancy among Black and/or Hispanic participants compared with their White counterparts. The data were split on hesitancy among Asian participants, with three studies reporting higher hesitancy and four reporting less hesitancy than their White counterparts. Ten studies examined correlations of age. Two of the 10 reported no statistically significant differences, whereas the other eight associated younger age with more hesitancy.

Of six articles that explored education, affirmed that lower educational status correlated with higher hesitancy. Studies reporting on occupations of physicians, or advanced practice

providers, correlated the roles with lower rates of hesitation or refusal. Notably, in the study of 8243 long-term care staff, nurses were found to be more hesitant than nursing aides by 5 percentage points, and Ciardi et al. found nurses and patient care associates to have the most hesitancy by profession.

Perceived risk was discussed in two ways: perceived occupational risk (exposure to infected patients) and perceived personal risk of infection (including comorbidities, self-reported health status, or concern over COVID-19 severity). Nine articles reported on perceived risk in some sense; however, the results were mixed. Three articles, comprising 20,800 participants, almost all from the Northeast (83%), reported that providing patient care correlated with higher hesitancy. Two articles of small sample size, varied location, and setting type reported perceived lower risk was statistically significantly associated with more hesitancy. Parente et al. found no statistically significant difference between vaccine acceptance and providing patient care or self-reported health in their study of 3347 workers, whereas Kocioleck et al. reported low levels of perceived risk, as well as having self-reported high-risk medical conditions were correlated with more hesitancy in their midwestern sample (N = 4277). Similarly, Kuter et al. found that self-reported poor/fair health status correlated with higher hesitancy (N = 12,034).

Twelve articles reported on safety concerns over vaccination within their samples. Safety concerns ranged from the rapidity of development to adverse reactions, long-term side-effects, and efficacy. Additional issues around politicization of the vaccines and/or a lack of trust in or transparency by the government or companies making the vaccines were reported by six publications. The most frequently cited reasons for hesitancy or refusal appeared to be the newness or perceived rush of development, and EUA, as well as the potential for side-effects.

**Table 2**  
Publication summaries.

Author/Pub Info	Aims	Sample - Setting, Time of data collection, and considerations	Results	Vaccine hesitancy or attitudes
Abohelwa, M. et al. <sup>27</sup> Primary authors discipline: Medicine <b>Article</b>	To understand residents and fellows' attitudes toward vaccination and record any side-effects after vaccination	81 residents and fellows South March 2021	77 (95.1%) accepted 3 (3.7%) refused <b>Other findings:</b> All 77 vaccinated reported pain at the injection site and headache in 49.4%	78 (96.3%) of the sample reported that they supported vaccination
Ciardi, F. et al. <sup>28</sup> Primary authors discipline: Medicine <b>Article</b>	This study was conducted about attitudes toward COVID-19 vaccination among healthcare workers at a public hospital in New York City during the beginning of COVID-19 vaccination	428 hospital workers* *physicians (28.5%), nurses (21.96%) Northeast December 2020 to January 2021	274 (64%) accepted 38 (8.9%) intended 116 (27%) refused <b>Statistically significant correlations</b> Gender: Males < hesitant Age: Older (65+) < hesitant Race: Asian least hesitant, Black most hesitant Ethnicity: Hispanic > hesitancy <b>Other significant associations:</b> Role within hospital, use of PPE, and perceived personal risk	The most predictive factors were prior vaccine attitudes and concern with the speed of testing and approval of the vaccines
Famuyiro, T. B. et al. <sup>29</sup> Primary authors discipline: Medicine <b>Article</b>	To assess the readiness for vaccine uptake among HCWs at three community-based, university-affiliated health centers	205 community-based workers* *physicians (40.5%), other clinical staff (44.4%) South December 2020	110 (54%) immediate intention 56 (27%) waiting 36 (18%) had no intention <b>Statistically significant correlations:</b> Gender: Males < hesitant Age: Older (65+) < hesitant Race: Asian least hesitant Black > hesitant than White Ethnicity: Hispanic > hesitant than White <b>Other significant associations:</b> moderate-risk perception < hesitance than those with low-risk perception	Most physicians (83%) and residents (81%) expressed more enthusiasm to receive the vaccine once it became available compared with other clinical staff (nurses, medical assistant, clinical technician, etc.; 31%)
Fontenot, H.B. et al. <sup>30</sup> Primary authors discipline: Nursing <b>Article</b>	To assess the intentions of licensed nurses in the State of Hawaii to obtain a COVID-19 vaccine and identify factors that are associated with nurses' intention to vaccinate	423 nurses West December 2020	221 (52%) intended 118 (27.9%) waiting 84 (19.9%) had no intention <b>Statistically significant correlations:</b> Age: Older (50+) < hesitant	The strongest predictors of any level of intention were greater positive attitudes toward COVID-19 vaccination and lower concerns related to COVID-19 vaccine safety
Fossen, M. C. et al. <sup>38</sup> Primary authors discipline: Nursing <b>Letter</b>	Examined vaccination rates of hospital workers by age, gender, department, and race to determine in which groups vaccine hesitancy was highest	3401 hospital workers South March 2021	2245 (71%) accepted 976 (29%) refused <b>Statistically significant correlations:</b> Age: Older (50+) < hesitant Race: Black > hesitancy than White <b>Other significant associations:</b> Working in a clinical department < hesitancy	
Gadoth, A. et al. <sup>39</sup> Primary authors discipline: Public Health <b>Letter</b>	To understand general vaccine acceptance and specific attitudes toward forthcoming coronavirus vaccines among HCWs in Los Angeles, California	540 healthcare workers* *prescribing clinicians 37.2%, registered nurses 38.3% West September to October 2020	179 (33%) immediate intention 354 (65.6%) waiting 7 (1.3%) had no intention <b>Correlations (p values unknown):</b> Age: Older (51+) < hesitant Race: Asian > hesitant than White Ethnicity: Hispanic > hesitant <b>Other findings:</b> Prescribing clinicians exhibited 20–30% less hesitant than other HCWs	46.9% of questioned the efficacy of vaccine Fast-tracking regulatory procedures and a lack of transparency were primary rationales for refusal or delay

Grumbach, K. et al. <sup>40</sup> Primary authors discipline: <i>Medicine</i> <b>Letter</b>	Investigated COVID-19 vaccine intentions among racially and ethnically diverse samples of HCW and the general population	1803 healthcare workers* *physicians, APPs and registered nurses (76.7%) West November 2020 to January 2021	1507 (83.6%) intended <b>Statistically significant correlations:</b> Race: White was least hesitant Asian > hesitant Black > hesitant (most hesitant) Multiple/other > hesitant Ethnicity: Hispanic > hesitant	Black, Latinx, and Asian respondents reported less confidence in vaccine efficacy, less trust in companies making the vaccine, and more worry that government rushed the approval process
Halbrook, M. et al. <sup>31</sup> Primary authors discipline: <i>Public Health</i> <b>Article</b>	The primary outcome of interest was COVID-19 vaccination intent and vaccine uptake among HCW	858 healthcare workers* *Advanced degree (59.8%) West September 2020 to February 2021	281 (32.8%) intended at survey 1 566 (68.8%) intended/accepted at survey 2 823 (96%) accepted at survey 3 <b>Statistically significant correlations:</b> Age: Older (50+) < hesitant Race*: Black > hesitancy than White Asian > hesitant than Black and White <i>*This relationship is seen with intention but not uptake</i> <b>Other significant associations:</b> Educational attainment was associated with intention and uptake	Among HCWs refusing the vaccine reasons included not having enough information or belief that the vaccine could infect them with COVID-19
Kociolek, L. et al. <sup>41</sup> Primary author's discipline: <i>Medicine</i> <b>Letter</b>	Assessing frequency of vaccine hesitancy, characteristics of those reporting vaccine hesitancy, specific concerns, and communication preferences among hospital workers	4448 hospital workers Midwest December 2020–January 2021	368 (8.6%) accepted 2559 (59.8%) intended 810 (18.9%) hesitant <b>Statistically significant correlations:</b> Gender: Males < hesitant Race: Black > hesitant than non-Black Ethnicity: Hispanic > hesitant <b>Other significant associations:</b> Hesitancy was associated with less concern about personal risk of severe COVID-19 and (three times) more prevalent in those with high-risk medical conditions.	Concerns reported were vaccine safety related to novelty and speed of the clinical development process
Kuter, B. J. et al. <sup>32</sup> Primary author's discipline: <i>Public Health</i> <b>Article</b>	To understand attitudes toward COVID-19 vaccines... to obtain a better understanding of how hospital employees, both in clinical and non-clinical positions, perceive the new COVID-19 vaccines and their intention to be vaccinated	12,034 hospital workers Northeast November to December 2020	7492 (63.7%) intended 4368 (36.3%) hesitant <b>Statistically significant correlations:</b> Gender: Males < hesitant Age: Older (65+) < hesitant Race: Black > hesitant than White Asian < hesitant Ethnicity: Hispanic > hesitant <b>Other significant associations:</b> Less hesitancy in those with up-to-date vaccinations, good-excellent self-reported health and no direct patient contact	Over 80% of vaccine hesitant reported concerns over side-effects and vaccines' newness 78% of hesitant reported not knowing enough of about the vaccine 33% questioned efficacy and 25% were concerned about getting COVID-19 from the vaccine
Meyer, M. N. et al. <sup>42</sup> Primary author's discipline: <i>Bioethics</i> <b>Letter</b>	To assess their intentions to [receive a COVID-19 vaccination], and understand reasons for hesitancy among HCW	16,292 healthcare workers Northeast December 2020	9015 (55.3%) intended 7277 (44.6%) hesitant <b>Significant associations:</b> Patient-facing employees were less hesitant than those who do not interact with patients	90.3% of vaccine hesitant reported concerns about unknown risks of the vaccines, 44.3% reported they wanted to wait until others' vaccine experiences are known, and 21.1% reported that they do not trust the rushed FDA process.
Pacella-LaBarbara, M. et al. <sup>33</sup>	To determine vaccine intent/uptake, perceived COVID-19 vulnerability, and	475 emergency department and EMS workers	337 (79%) accepted or intended 98 (21%) had no intention	Those with a higher perceived COVID-19 vulnerability had

(continued on next page)

Table 2 (continued)

Author/Pub Info	Aims	Sample - Setting, Time of data collection, and considerations	Results	Vaccine hesitancy or attitudes
Primary author's discipline: <i>Health psychology</i> <b>Article</b>	factors associated with vaccine intent/ uptake.	Mid-Atlantic January 2021	<b>Statistically significant correlations:</b> Gender: Males < hesitant <b>Other significant associations:</b> Those with a history of COVID-19 infection had lower intention Those with an advanced degree had higher intention/uptake (zero physicians reported no intention) 115 (73.2%) accepted 6 (3.8%) hesitant 36 (23%) waiting/unknown intent <b>Other findings:</b> Reasons for delay included: recent COVID-19 infection, leave of absence from work, and pregnancy or breastfeeding	higher rates of intention or uptake
Pamplona, G. M. et al. <sup>43</sup> Primary author's discipline: <i>Unknown</i> <b>Letter</b>	To report dialysis staff vaccination acceptance and hesitancy rates from four Renal Research Institute dialysis clinics and a home dialysis program located in New York, New York.	157 community-based healthcare workers Northeast January 2021	1241 (37%) intended 1764 (52%) waiting 331 (10%) had no intention <b>Statistically significant correlations:</b> Gender: Males < hesitant Race: Black > hesitant than White <b>Other significant associations:</b> Prior influenza vaccination, increased concern about COVID-19, and postgraduate education were associated with vaccine acceptance	Barriers to vaccination included concerns about long-term side- effects (57.1%), safety ( <i>n</i> = 55.0%), efficacy (37.1%), and risk-to-benefit ratio (31.0%)
Parente, D. J. et al. <sup>34</sup> Primary author's discipline: <i>Medicine</i> <b>Article</b>	To evaluate HCW willingness to become vaccinated against COVID-19 and identified barriers/facilitators to vaccine uptake among all personnel at a large academic medical center in the Midwest	3347 healthcare workers Midwest August 2020	Results: 1136 (86%) received vaccine <b>Correlations (p value unknown):</b> Non-Hispanic Black HCWs had the lowest vaccine acceptance rate <b>Other findings:</b> Physicians and APPs had the lowest refusal rate (5.5% of 674), compared with nurses (22.3% of 345) and non-clinical HCWs (23.5% of 302) Vaccinated recipients planned to use the same amount of PPE at work as well as in public	The primary reason for declining a COVID-19 vaccine was concern about vaccine safety (45.4%)
Schrading, W. A. et al. <sup>44</sup> Primary author's discipline: <i>Medicine</i> <b>Letter</b>	To describe differences in vaccination rates among various types of ED HCP at US academic medical centers and reasons for declining vaccination	1321 Emergency Department hospital workers* *physicians/APP 49.4%, registered nurses 25.75% Multiple US regions January 2021	3032 (57.5%) intended 2245 (42.5%) hesitant <b>Statistically significant correlations:</b> Gender: Males < hesitant Age: Older (65+) < hesitant Race: Asian least hesitant Black > hesitant than White <b>Other significant associations:</b> 80.4% of physicians and scientists intended to get vaccinated, compared with 51.4% of allied health professionals and 41.2% of nurses More non-care providers indicated they would take the vaccine if offered	Vaccine safety, potential adverse events, efficacy, and speed of vaccine development dominated concerns listed by participants
Shaw, J. et al. <sup>35</sup> Primary author's discipline: <i>Medicine</i> <b>Letter</b>	To provide a snapshot of vaccination attitudes in order to identify areas of concern that would impinge on COVID- 19 vaccination program planning and implementation	5287 hospital workers North East November to December 2020	1247 (36%) intended 1953 (56%) waiting 279 (8%) had no intention <b>Statistically Significant Correlations</b> Gender: Males < hesitant Age: Older (60+) < hesitant Race: Asian least hesitant Black > hesitant than White Ethnicity: Hispanic > hesitant <b>Other significant associations:</b> HCWs working in rural areas had more hesitancy Direct medical care providers, those with professional or doctoral degrees and those with prior flu vaccination had higher intention	Safety (69%), effectiveness (69%), and speed of development/approval (74%) were noted as the most common concerns regarding COVID-19 vaccination in our survey
Shekhar, R. et al. <sup>36</sup> Primary author's discipline: <i>Medicine</i> <b>Article</b>	To assess the attitude of HCWs toward COVID-19 vaccination	3479 healthcare workers *professional or graduate degree 32.5%, Multiple regions October–November 2020		

Concerns about side-effects was the primary reason for vaccine hesitancy (70%) other non-mutually exclusive reasons given were health concerns (34%), questioning the effectiveness (20%), and religious reasons (12%). In addition, 23% of respondents provided other reasons they would be unwilling to receive the vaccine such as concerns it is “too new,” a lack of trust, the need for more research, or it was too political

3704 (45%) intended  
2001 (24%) waiting  
2523 (31%) had no intention  
**Statistically significant correlations:**  
Gender: Males < hesitant  
Age: Older (60+) < hesitant  
Race: Black > hesitant  
**Other significant associations:**  
Clinical care staff, including nurse aides and nurses in clinical roles, were less likely than dietary, housekeeping, and administrative staff to report willingness to receive the vaccine  
Nurses providing direct clinical care were –5 percentage points less likely to indicate a willingness to take the vaccine than nurse aides or similar role

8243 long-term care staff  
Midwest  
November 2020

To plan for coronavirus infectious disease 2019 (COVID-19) vaccine distribution, the Indiana Department of Health surveyed nursing home and assisted living facility staff.

Untroe, K. T. et al.<sup>37</sup>  
Primary author's discipline: Medicine  
**Article**

FDA, Food and Drug Administration; HCW, healthcare workers.

**Table 3**  
Demographic variables of study participants.

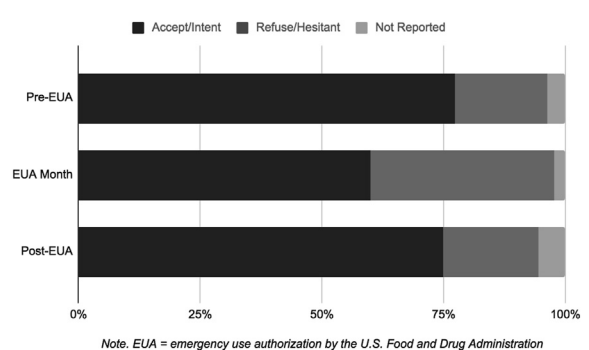
<b>Gender</b>	N = 46,279
Female	35,084
Male	9716
Not reported	1479
<b>Age</b>	N = 36,693
<40	16,883
>40	14,695
<45	2571
>45	1487
Not reported	1057
<b>Race</b>	N = 46,198
White	30,114
Black	3947
Hispanic/Latinx	758
Asian	2316
Other	3452
Not reported	5611
<b>Ethnicity</b>	N = 19,886
Hispanic/Latinx	5134
Non-Hispanic/Latinx	6607
Not reported	8145

Four articles examined prior vaccination status and occurred prior hesitancy or refusal correlated with hesitancy or refusal of COVID-19 vaccination.<sup>28,32,34,36</sup> Two studies reported on geographic differences found those living in rural areas had more hesitancy.<sup>32,36</sup>

**Discussion**

The findings of this review reflected a group of timely publications regarding the COVID-19 vaccination rollout with a particularly at-risk occupational group, HCWs. Overall, we found that estimates of vaccine hesitancy among HCWs were similar to the general population. Demographic characteristics associated with vaccine hesitancy included being younger, female, Black, Hispanic, or Latinx; however, examination of the demographic data also points to gaps in the understanding and implications of those characteristics. Furthermore, the newness or perceived rush of vaccine development and implementation were the most cited sources for hesitancy.

The urgency to disseminate data on the topic is demonstrated by the number of letters included, despite their inability to provide rigorous details as articles can. As all samples were convenient, and one was a snowball, all had the potential for selection or response bias and constraints on generalizability because of their non-probability sampling structures. Over- or under-representation of responder subgroups, including by



**Fig. 2.** Vaccine acceptance/intention vs refusal/hesitance by EUA.



vaccination status or intentionality, may influence the robustness or magnitude of observed correlations. Overall, no study adequately addressed sample size justification, three studies included information on their reference population, and just one study tried to categorize and account for non-response bias (Table 1). Furthermore, lack of standardization is apparent in the data reporting above.

On the surface, the data presented from the 18 studies in this review echo the trends observed in the US adult population, citing higher hesitancy among those that are female, younger, Black, or Hispanic/Latinx. However, how race and ethnicity are reported and how studies manage missing data may alter the reporting of resulting correlations.<sup>45</sup> Within the overall sample, race and ethnicity had the highest rate of undisclosed data out of the variables. The divergence of data regarding Asian participant's hesitancy may be related to more granular details regarding country of origin. Such data are necessary when Filipino nurses make up roughly 4% of the nursing workforce and share a disproportionate amount of COVID-19 cases and death, along with their Black counterparts.<sup>46</sup> Furthermore, no research included information on foreign-born workers, who currently make up 4.1 million workers in the healthcare and social assistance industry.<sup>47</sup>

In addition, the lack of female-specific concerns as well as the role nursing could play in the vaccine discourse should also be examined. The data upheld that females have greater hesitancy; however, Halbrook et al.<sup>31</sup> posit that they then have a higher rate of vaccination acceptance. Ciardi et al.<sup>28</sup> posit in the discussion that intention is lower for women of any age, which questions the importance of fertility and childbearing in vaccine decision-making. Of the postvaccine rollout literature, Pamplona et al.<sup>43</sup> and Schradang et al.<sup>44</sup> were the only publications to report refusal based on the discrete variables of fertility, pregnancy, or breastfeeding. Given that more than 70% of the HCW population is female, more than half of childbearing age, lack of these data warrants future study.

It is noteworthy that the clinical trials of vaccines did not include pregnant or lactating women.<sup>48</sup> However, all major reproductive health organizations recommend pregnant women receive the vaccine.<sup>49</sup> As HCWs are majority female, these concerns must be included in the discourse, even if to rule out their influence. This may be even more salient as concerns over vaccine development and approvals were indicated as a primary reason for hesitancy, especially within the female population.

Similarly, nursing is predominantly female, the largest sector of the healthcare industry at roughly four million workers, and consistently voted the most trusted profession.<sup>50,51</sup> Yet nursing is largely absent from the scholarly discourse around vaccination hesitancy. Only two publications had a nurse as lead author,<sup>30,38</sup> and an additional two disclosed having a nurse as a non-primary author.<sup>37,41</sup> Furthermore, nurses have higher rates of hesitancy than their medical counterparts. In March of 2021, 30% of nurses had not been vaccinated.<sup>52</sup> Of those reporting refusals, half indicated concerns about information scarcity and vaccine development and approvals. Currently, the American Nurses Association reports approximately 11% of nurses remain hesitant and 42% are against mandates.<sup>53</sup> As mandates are rising in prevalence, vaccination or termination laws have the potential to exacerbate staffing shortages,<sup>54</sup> which could impact care provision and the well-being of nursing staff.

The studies in this review give clear areas of need within the discourse, including comorbid, diasporic, and reproductive health concerns. Anecdotally, worries about pregnancy persist despite vaccine recommendations from credible sources, such as the American College of Obstetrics and Gynecology, American College

of Nurse-Midwives, and Society for Maternal-Fetal Medicine<sup>49</sup> and research to the contrary, indicating rather that infection with the COVID-19 virus poses a higher risk than vaccination.<sup>55–60</sup> Translational research on dissemination and implementation is a priority area for those focused on worker health.<sup>3</sup>

Global populations are increasingly subject to mis- and dis-information with the use of social media and communication apps. The COVID-19 infodemic<sup>21</sup> or ubiquity of information, including false and misleading information, can influence health behaviors, including vaccine intention.<sup>20,61–63</sup> In the climate of the pan- and info-demics, America is marching toward mandates as the Supreme Court upheld the Biden administration mandate for HCWs.<sup>64</sup> However, it is unclear if vaccination mandates will extend beyond a yearly requirement, including booster doses, how many HCWs would resign rather than be vaccinated or how many may be covered by religious or medical exemptions. The effects of mandates on HCW employment, and potentially worker shortages, may not be felt immediately.

Mandates may be seen as an efficient and socially just way to increase vaccination<sup>65</sup> and America is not alone in pursuing them, with other countries, including Germany, France, and Italy, mandating HCW vaccination.<sup>66,67</sup> Vaccination Injury Compensation Programs (VICP) are available in 16 European nations, Canada, and Australia, some regardless of COVID-19 vaccination mandates.<sup>68</sup> Given that fear of side-effects was present in the literature as a source of hesitancy, such safeguards are justified and necessary. Currently, the US does have a VICP; however, it has not been extended to COVID-19 vaccinations. The United States has a Countermeasure Injury Compensation Program, but it is not as expansive or easy to apply to as VICP.<sup>69</sup>

An alternate to vaccine mandates could include the use of personal protective equipment (PPE) and testing measures; however, under the current mandate, employers are not required to pay for testing. This may target the vaccine hesitant, as the additional cost of frequent testing could prove substantial and unsustainable.<sup>69</sup> Other adjunctive alternatives could be explored, such as the use of spatial modeling to guide vaccination efforts through geographic targeting.<sup>70</sup> Specific targeting, based on correlational data may be further enhanced by the concept of nudging interventions, which may include incentives, reminders, and reframing information dissemination.<sup>71,72</sup>

## Conclusion

HCWs continue to battle the COVID-19 crisis and exhibit vaccination hesitancy. Correlates of hesitancy among HCWs appear to mimic correlates found in the general population, but additional areas of investigation could give further clarity to the complex nature of vaccine hesitancy. This review of the literature was impacted by the asynchronicity of data reporting, which made comparisons difficult and limited the synthesis of information. The gravity of the pandemic and the quick arrival of the COVID-19 vaccine is happening concurrently with an infodemic, in which large amounts of mis- or dis-information are being spread and to which HCWs may not be immune. Implications of findings may evolve as trends shift in vaccination and acceptance. The United States could look to policies of other nations as well as alternative interventions to combat hesitancy as an adjunct to mandates.

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## Competing interests

None declared.

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Original Research

# Willingness to pay for SARS-CoV-2 rapid antigen tests during the COVID-19 pandemic: evidence from the general adult population

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## ABSTRACT

**Objective:** Our aim was to examine the willingness to pay (WTP) for SARS-CoV-2 rapid antigen tests and its correlates during the COVID-19 pandemic in Germany.

**Study design/Methods:** A representative online survey was conducted in late summer 2021 (with  $n = 3075$ ; the average age was 44.5 years; 14.8 years ranging from 18 to 70 years) in Germany. Two-part models were conducted. Various correlates (such as empathy or altruism) were included in the regression analysis.

**Results:** The average WTP for SARS-CoV-2 rapid antigen tests (in euros) was 6.6 (standard deviation 8.4) in the general adult population. It markedly differed between subgroups (e.g. the average WTP was 2.9 among individuals not vaccinated against COVID-19 and 7.5 among individuals vaccinated against COVID-19; it was 5.4 among the lowest income decile, whereas it was 8.6 among the highest income decile). Regressions showed that a higher WTP for SARS-CoV-2 rapid antigen tests was associated with being male, being in the highest income group, being vaccinated against COVID-19, and having higher levels of empathy.

**Conclusions:** As the very first study in this area, our study described WTP for SARS-CoV-2 rapid antigen tests and some interesting differences between population subgroups. In particular, individuals not vaccinated against COVID-19 reported a low WTP for SARS-CoV-2 rapid antigen tests. Approximately one-fourth of the sample reported a WTP for SARS-CoV-2 rapid antigen tests of €0 among individuals vaccinated against COVID-19, whereas approximately two-thirds of those not vaccinated against COVID-19 reported such a WTP. Knowledge about the WTP for COVID-19 rapid antigen tests is important for policy makers (e.g. for testing strategies) during this pandemic. It may also give a rough estimation of the acceptance of such rapid tests.

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## Introduction

Since March 2020, individuals in Germany have been contending with the consequences of the ongoing COVID-19 pandemic. A few months after the start of the pandemic, tests (e.g. polymerase chain reaction tests) were used to quickly identify infected persons and put in place appropriate measures (e.g. isolation and tracing of contact persons).<sup>1,2</sup> Later in 2020, SARS-CoV-2 rapid antigen tests (and also self-tests) became available in Germany. Many corona

rapid testing centers opened in Germany in spring 2021, with many testing options being relatively quick, widespread, and relatively inexpensive. Such testing services are perceived as having great potential in the global fight against the pandemic.<sup>3,4</sup>

There are some studies on readiness for a COVID-19 vaccine in Germany (e.g. <sup>7</sup>). These studies also showed a high readiness for rapid testing (from December 2020 to March 2021).<sup>5</sup> For example, the likelihood of using such a test was positively associated with low price and ease of use.<sup>5</sup> Moreover, although various studies in different countries and subgroups examined the willingness to pay (WTP) for a (hypothetical) COVID-19 vaccine,<sup>5–11</sup> there are not currently any studies regarding the WTP for SARS-CoV-2 rapid antigen tests (in Germany and also globally). Generally, a WTP refers to a maximum amount of money an individual is willing to spend for a certain product or service.<sup>12</sup>

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Such knowledge is important for policy makers (e.g. for testing strategies) during the COVID-19 pandemic. Moreover, knowledge about the WTP for SARS-CoV-2 rapid antigen tests may give a rough estimation of the acceptance of such rapid tests in the general adult population and in certain subgroups (such as individuals not vaccinated against COVID-19). Thus, our aim was to examine the WTP for SARS-CoV-2 rapid antigen tests and its correlates in Germany in late summer 2021.

It is worth noting that during the time of data collection (late August to early September 2021), such rapid tests were free of charge in Germany. However, during that time, the German government had already announced that such rapid tests would no longer be free of charge from October 2021.

## Methods

### Sample

The data came from a representative online survey of 3075 adults in Germany aged 18–70 years. Only people aged <18 or >70 years, as well as those who did not live in Germany, were excluded. It should be noted that the questionnaire was only available in German. Fieldwork took place from late August to early September 2021. The individuals were recruited by a well-known market research institute using its own online access panel.

Individuals were drawn from this online sample in such a way that they reflected the distribution of gender, age bracket, and federal state in the German adult population.<sup>13</sup> Quotas were derived from Best for Planning 2020. An invitation to participate was sent to approximately 14,000 individuals. As this was an online survey, potential differences between respondents and non-respondents could not be examined.

With regard to the representativeness, for example, in the German Socio-Economic Panel (GSOEP), the median household net income was similar compared with our study (GSOEP: about 2200 euros in the year 2018 [continuously assessed] vs in our study: 2500–3000 Euro [income category; late Summer 2021]).<sup>13</sup> Moreover, the proportion of unemployed individuals was 5.7% according to the German Federal Employment Agency in the year 2021, and this proportion equaled 5.6% in our present study. However, while about 11.4% of the individuals had a migration background in our study, 26.7% of the individuals had a migration background according to the microcensus.<sup>14</sup>

All participants in the study provided written informed consent. The Local Psychological Ethics Committee of the Center for Psychosocial Medicine of the University Medical Center Hamburg-Eppendorf approved the study (number: LPEK-0356).

### Outcomes

Individuals self-reported the WTP for SARS-CoV-2 rapid antigen tests (in euros). It was introduced as follows: “Currently, the costs for rapid tests are covered by the state. From October, the rapid tests for the unvaccinated will no longer be free of charge. What is the maximum amount you would be willing to pay for such a rapid test?” (options: €0; €5; €10; €15; €20; €25; €30; €35; €40; more than €40). Values of “more than €40” were transformed to €45 to calculate an average WTP.

It should be noted that two concepts exist to calculating WTP: revealed preferences and stated preferences. Revealed preferences can be quantified by using, for example, natural field experiments or laboratory experiments. In contrast, stated preferences can be quantified using indirect surveys (e.g. conjoint analysis) or direct survey approaches. In our study, the stated preference concept via a direct survey approach was applied.

### Independent variables

In regression analysis, we included the following factors as correlates: sex (women, men, and diverse), age, presence of at least one child in own household (no or yes), marital status (married, not living together with spouse; divorced; widowed; and single), education (upper secondary school, qualification for applied upper secondary school, polytechnic secondary school, intermediate secondary school, lower secondary school, currently in school training/education, and without school-leaving qualification), having a migration background (no or yes), employment situation (full-time employed, retired, and other), household net income in Euro (trichotomized into lowest income decile, second to ninth income decile, and highest income decile), being vaccinated against COVID-19 (no or yes), and long-term illnesses (absence of chronic diseases and presence of at least one chronic disease).

Moreover, we included empathy (ability to imagine what life is like for another individual<sup>15</sup>) and altruism (referring to disinterestedness and selflessness<sup>16</sup>). Based on the short scale of the Interpersonal Reactivity Index<sup>15</sup> (German version: Saarbrücken personality questionnaire, SPF<sup>17</sup> – short version: SPF-K), empathy was assessed. This tool consists of four items.<sup>18</sup> A sum score was calculated (which ranges from 4 to 20, higher values correspond to higher levels of empathy). Cronbach's alpha was 0.81 in our study. The subscale “altruism” of the International Personality Item Pool (IPIP–5F30F–R1<sup>19</sup>) was used, which consists of six items. All items were recoded. Thereafter, the score was generated by averaging all items (ranging from 1 to 5, with higher values reflecting higher altruism). Cronbach's alpha was 0.87 in our study.

### Statistical analysis

Initially, the average WTP for SARS-CoV-2 rapid antigen tests in Euro was displayed (total sample and by some subgroups). Thereafter, two-part models<sup>20</sup> were conducted to analyze the correlates of WTP for SARS-CoV-2 rapid antigen tests (first part: logit model; second part: generalized linear model with gamma distribution and log link function; taking into account the skewed distribution of positive values<sup>21</sup>). Such models are frequently used when the proportion of zero values is large (i.e. absence of WTP for SARS-CoV-2 rapid antigen tests in our study). The “twopm” command in Stata was used to conduct the two-part models.<sup>20</sup> We calculated average marginal effects due to ease of interpretation. They indicate the change in WTP for SARS-CoV-2 rapid antigen tests (in euros) associated with a one unit change in the correlates (or the difference to the reference category, in the case of categorical variables).

Statistical significance was defined as *P* value of 0.05 or smaller. Stata 16.1 (Stata Corp., College Station, TX) was used to conduct statistical analyses.

## Results

### Sample characteristics

In our total sample, the average age was 44.5 years (standard deviation [SD] 14.8 years). It consisted of 51.1% female individuals. In [Supplementary Table S1](#), we provide a comparison of our sample and the target cohort (sex, age group, and state). The average WTP for SARS-CoV-2 rapid antigen tests (in euros) is presented in [Table 1](#) (total sample and stratified by subgroups). In the total sample, the average WTP for SARS-CoV-2 rapid antigen tests (in euros) was 6.6 (SD 8.4). In the subgroups, the average WTP for SARS-CoV-2 rapid antigen tests (in euros) ranged between 2.9 (among individuals not vaccinated against COVID-19) and 7.5 (among individuals vaccinated against COVID-19). Further details are given in [Table 1](#). In



**Table 1**  
Average WTP for SARS-CoV-2 rapid antigen tests (in euros) stratified by various subgroups.

Independent variables	N	Average WTP for SARS-CoV-2 rapid antigen tests (in euros)	P value
Total sample	3075	6.6 (8.4)	
Gender			<0.01
Male	1502	7.2 (9.3)	
Female	1570	6.1 (7.3)	
Diverse	3	6.7 (7.6)	
Age group			<0.01
18–29 years	628	5.7 (6.8)	
30–39 years	597	6.5 (8.7)	
40–49 years	597	6.4 (8.2)	
50–59 years	659	7.3 (8.5)	
60 years and older	594	7.1 (9.4)	
Children in own household			0.70
No	2206	6.6 (8.3)	
Yes	869	6.7 (8.5)	
Marital status			<0.01
Single/divorced/widowed/married, not living together with spouse	1313	6.1 (8.0)	
Married, living together with spouse	1762	7.0 (8.6)	
Education			0.73
Upper secondary school	1326	6.9 (8.1)	
Qualification for applied upper secondary school	328	6.6 (9.6)	
Polytechnic secondary school	168	6.5 (9.5)	
Intermediate secondary school	888	6.3 (7.9)	
Lower secondary school	347	6.4 (8.5)	
Currently in school training/education	9	5.0 (5.6)	
Without school-leaving qualification	9	5.6 (9.8)	
Migration background			0.79
No	2724	6.6 (8.3)	
Yes	351	6.7 (8.5)	
Employment status			<0.05
Full-time employed	1458	6.9 (8.6)	
Retired	499	7.0 (9.4)	
Other	1118	6.0 (7.5)	
Vaccinated against COVID-19			<0.001
No	593	2.9 (5.4)	
Yes	2482	7.5 (8.7)	
Chronic diseases			0.93
Absence of at least one chronic disease	1765	6.6 (8.3)	
Presence of at least one chronic disease	1310	6.6 (8.5)	
Household net income			<0.001
Lowest income decile	328	5.4 (8.8)	
Second to ninth income decile	2006	6.4 (7.8)	
Highest income decile	427	8.6 (9.8)	

Notes: One-way analyses of variance or independent *t*-tests were conducted, as appropriate (*P* values). WTP, willingness to pay.

addition, it may be worth noting that 34.5% of the individuals reported a WTP for SARS-CoV-2 rapid antigen tests of €0. This proportion markedly differed according to income (individuals in the lowest income decile: 43.3%; individuals in the highest income decile: 25.5%) and particularly according to vaccination status (individuals not vaccinated against COVID-19: 63.9%; individuals vaccinated against COVID-19: 27.5%).

Significant differences in the average WTP for SARS-CoV-2 rapid antigen tests between the subgroups were identified according to gender, age group, marital status, employment status, and vaccination status.

With regard to effect sizes, although most differences in average WTP for SARS-CoV-2 rapid antigen tests between the subgroups were quite small, particularly the difference in average WTP for SARS-CoV-2 rapid antigen tests between individuals vaccinated against COVID-19 and individuals not vaccinated against COVID-19 was notable (Cohen's *d* = 0.57). Furthermore, there were some differences in average WTP between individuals in the lowest income decile and individuals in the highest income decile (Cohen's *d* = 0.34).

### Regression analysis

To check for multicollinearity, we calculated the variance inflation factors (VIF). The highest VIF was 2.7 (highest income group), with an average VIF of 1.4, indicating that multicollinearity is not a threat.

Two-part models are displayed in Table 2. It is worth repeating that the first part refers to a logit model, and the second part refers to a generalized linear model with gamma distribution and log link function. The likelihood of reporting a WTP for SARS-CoV-2 rapid antigen tests higher than zero (first part: logit model) was positively associated with a high educational level, being in the highest income decile, being vaccinated against COVID-19 and having a higher empathy level. The extent of WTP (conditional on a WTP for SARS-CoV-2 rapid antigen tests higher than zero; second part) was positively associated with being male and being vaccinated against COVID-19. In addition, average marginal effects (last column in Table 2) showed that higher WTP for SARS-CoV-2 rapid antigen tests was significantly associated with being male, being in the highest income decile, being vaccinated against COVID-19 and higher levels of empathy.

**Table 2**  
Two-part models with WTP for SARS-CoV-2 rapid antigen tests (in euros) as outcome measure (1. Logit 2. GLM<sup>a</sup>).

Independent variables	Logit OR (SE)	GLM b (SE)	Predict. margin
Sex			
Women (Ref.: men)	1.09 (0.10)	−0.17*** (0.04)	−0.92** (0.33)
Diverse	1.49 (3.04)	0.04 (0.33)	1.10 (4.80)
Age	1.00 (0.00)	0.00 (0.00)	0.01 (0.01)
Marital status: married, living together with spouse (Ref.: single/divorced/widowed/married, not living together with spouse)	1.03 (0.10)	−0.02 (0.04)	−0.07 (0.33)
Highest educational degree			
Qualification for applied upper secondary school (Ref.: upper secondary school)	0.61*** (0.09)	0.09 (0.07)	−0.48 (0.55)
Polytechnic secondary school	0.85 (0.16)	0.12 (0.10)	0.47 (0.86)
Intermediate secondary school	0.93 (0.10)	−0.00 (0.05)	−0.16 (0.37)
Lower secondary school	0.87 (0.13)	0.04 (0.07)	0.01 (0.53)
Currently in school training/education	0.37 (0.32)	−0.16 (0.15)	−2.75 (1.74)
Without school-leaving qualification	0.44 (0.37)	0.18 (0.30)	−0.74 (2.84)
Children in own household: Yes (Ref.: No)	0.88 (0.09)	0.07 (0.04)	0.23 (0.36)
Migration: Migration background (Ref.: no migration background)	0.94 (0.13)	0.03 (0.06)	0.08 (0.47)
Employment status			
Retired (Ref.: Full-time employed)	0.80 (0.11)	0.06 (0.07)	−0.10 (0.53)
Other	0.94 (0.10)	−0.00 (0.04)	−0.15 (0.36)
Income			
Second to ninth income decile (Ref.: lowest income decile)	1.23 (0.18)	−0.00 (0.08)	0.40 (0.58)
Highest income decile	1.75** (0.35)	0.14 (0.10)	2.14** (0.76)
Chronic diseases: presence of at least one chronic disease (Ref.: absence of chronic diseases)	0.90 (0.08)	0.00 (0.04)	−0.19 (0.32)
Vaccinated against COVID-19: Yes (Ref.: No)	4.50*** (0.48)	0.23*** (0.06)	4.49*** (0.43)
Empathy	1.09*** (0.02)	0.01 (0.01)	0.21*** (0.06)
Altruism	1.13+ (0.08)	−0.01 (0.03)	0.20 (0.27)
Constant	0.13*** (0.04)	1.96*** (0.17)	
Observations	2761	2761	2761

Two-part models with WTP for SARS-CoV-2 rapid antigen tests (in euros) as outcome measure<sup>a</sup>; Generalized linear model (GLM) with log link and gamma distribution; OR = odds ratio; robust standard errors (SE) in parentheses; \*\*\* $P < 0.001$ ; \*\* $P < 0.01$ ; \* $P < 0.05$ ; + $P < 0.10$ .

## Discussion

Using data from the general adult population in Germany, this is the very first study quantifying the WTP for SARS-CoV-2 rapid antigen tests and its correlates during the COVID-19 pandemic – and consequently forms a basis for future research. It should be emphasized that rapid test centers charged around 15€ for SARS-CoV-2 rapid antigen tests in Germany in October 2021. However, due to the increase in the number of cases, these SARS-CoV-2 rapid antigen tests are already free of charge again (mostly since November 2021).

Compared with other groups, particularly individuals not being vaccinated against COVID-19 reported a rather low WTP for SARS-CoV-2 rapid antigen tests. In addition, regressions showed that a higher WTP for SARS-CoV-2 rapid antigen tests was associated with being male, being in the highest income decile, being vaccinated against COVID-19 and higher levels of empathy.

It appears to be plausible for us that not being vaccinated against COVID-19 was associated with much lower levels of WTP for SARS-CoV-2 rapid antigen tests in our study. The findings from the European COvid Survey (September 2021) showed that different reasons for not getting vaccinated against COVID-19 exist in Germany such as that the respondents did not want to support the profit-striving of global vaccine producers or they did not think that COVID-19 vaccines are safe enough.<sup>22</sup> These reasons may also reflect that such individuals also do not want to support manufacturers of rapid tests and do not have much trust in the accuracy of such rapid tests. This could be a politically important outcome: The fact that they have to pay for such tests is probably a deterrent to testing, particularly for the individuals not being vaccinated against COVID-19, for whom the tests are likely most important.

Those who refuse vaccination probably see less danger in infection. However, future research is required to elucidate the underlying mechanisms.

Moreover, individuals in the highest income decile reported a higher WTP for SARS-CoV-2 rapid antigen tests in our study compared with individuals in the lowest income decile. Such income discrepancies may particularly reflect differences in financial opportunities. Moreover, such individuals in the highest income decile may have a higher trust in the accuracy of such rapid tests compared with individuals in the lowest income decile and may thus report a higher WTP for SARS-CoV-2 rapid antigen tests.

Our study also showed an association between higher empathy and a higher WTP for SARS-CoV-2 rapid antigen tests. Such a link appears quite plausible because empathy is also positively associated with prosocial behavior, such as donating blood<sup>23</sup> and also wearing face masks during the pandemic.<sup>24</sup> Individuals scoring high in empathy may therefore appreciate rapid tests because of their potential in the fight against COVID-19. Surprisingly, altruism was only marginally significantly associated with a higher likelihood of reporting a WTP for SARS-CoV-2 rapid antigen tests higher than zero. Future research is required to clarify this association in further detail.

Some strengths and limitations of our present study are worth acknowledging. This is the very first study quantifying the WTP for SARS-CoV-2 rapid antigen tests during the pandemic. Data were taken from a large, representative study. However, the questionnaire was only available in the German language. Thus, it is very likely that individuals with a migration background are underrepresented. Moreover, the general possibility of an online bias cannot be dismissed. Established tools were used to quantify the

correlates. A single item was used to assess WTP (preference concept via a direct survey approach was applied). Advantages of such an assessment include its high face validity, as well as its simple and efficient assessment of WTP. However, further research with more sophisticated tools to measure WTP is desirable because such direct survey approaches may lead to the fact that the true WTP is not being identified. For example, indirect survey methods such as conjoint analyses or discrete choice analyses could be used. Moreover, further research is required using data from the oldest old because our study only included individuals aged 18–70 years. In addition, longitudinal studies are required to confirm our findings.

In conclusion, our study revealed the WTP for SARS-CoV-2 rapid antigen tests and also revealed some interesting differences between subgroups. Particularly, individuals not being vaccinated against COVID-19 reported a low WTP for SARS-CoV-2 rapid antigen tests. Approximately one-fourth reported a WTP for SARS-CoV-2 rapid antigen tests of €0 among individuals being vaccinated against COVID-19, whereas approximately two-thirds reported such a WTP among individuals not being vaccinated against COVID-19. Knowledge about the WTP is important for policy makers (e.g. for testing strategies) during this pandemic. It may also give a rough estimation of the acceptance of such rapid tests.

### Author statements

#### Ethical approval

Approval for the study was provided by the Local Psychological Ethics Committee of the Center for Psychosocial Medicine of the University Medical Center Hamburg-Eppendorf (number: LPEK-0356). Our study is in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

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#### Competing interests

None.

#### Consent to participate

All participants included in this study provided informed consent.

#### Consent to publish

Not applicable.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2022.03.016>.

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