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RESEARCH PAPER

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COVID-19 vaccine hesitancy and resistance in an urban Chinese population of Hong Kong: a cross-sectional study

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ABSTRACT

Vaccine hesitancy against COVID-19 is prevalent. This study aimed to identify the factors associated with COVID-19 vaccination compliance among adults in Hong Kong. An online survey was conducted during an early stage of community-based COVID-19 vaccination campaign in Hong Kong. The questionnaire consisted of vaccine status, sociodemographic information, risk perception of being infected by COVID-19, and exposure to confirmed COVID cases, as well as items on sleep and mental health. The association between these variables and vaccine hesitancy was analyzed. Among the 883 participants (67.5% females, 54.5% aged 18–39), 30.6% had low vaccine hesitancy, 27.4% had high vaccine hesitancy, and 27.5% had vaccine rejection. The likelihood of having high vaccine hesitancy was higher among young (adjusted odds ratio [*aOR*] = 2.99; 95% confidence interval [CI]: 1.23–7.30) and middle-aged respondents (*aOR* = 2.99; 95% CI: 1.07–5.47) than among old respondents. Moreover, those who were married (*aOR* = 0.51; 95% CI: 0.29–0.88), had a full-time job (*aOR* = 0.55; 95% CI: 0.29–0.88), and had a greater confidence in the government (*aOR* = 0.68; 95% CI: 0.54–0.86) were less likely to exhibit vaccine hesitancy. Our findings showed that the prevalence of vaccine hesitancy and vaccine resistance were high. Policy makers need specific strategies to target those who may have a high risk of vaccine hesitancy and resistance.

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Vaccination; pandemic; observational; survey; herd immunity

Introduction

Outbreaks of coronavirus disease 2019 (COVID-19) are currently among the major threats to public health worldwide. The development of a safe and effective vaccine is crucial to decreasing the death rate due to COVID-19. High levels (e.g., 70%–80%) of vaccine uptake are essential to achieve herd immunity and decrease the risk of virus transmission.[1] However, despite the availability of vaccines and vaccination services, their acceptance among the global population is low, and less than 15% are fully vaccinated.[2]

The World Health Organization (WHO) has identified "vaccine hesitancy" as one of the top 10 threats to public health.[3] Vaccine hesitancy is defined as a "delay in the acceptance or refusal of vaccination despite the availability of vaccination services".[4] In the context of COVID-19, national representative surveys in Europe, Australia, and the United States of America have revealed that vaccine hesitancy ranges from 12% to 36%.[5–8] The prevalence of vaccine hesitancy varies across regions, with rates higher (over 40%–80%) in some Asian and Middle East countries.[9,10] Notably, the hesitancy rate is higher than the proportion of those who object to vaccines (vaccine resistance), which accounts for 5%–10% of the study populations,[5–7] indicating that addressing hesitancy rate may have a crucial effect on the overall vaccine acceptance.

An increasing number of studies on COVID-19 vaccines have identified various factors associated with vaccine hesitancy, namely concerns over safety, conspiracy beliefs or suspicion about political or economic forces driving the vaccine development, lack of knowledge or confidence about the vaccine, and inconsistent or confusing messages from authorities.[11–13] A local survey before the vaccination program found that safety concerns are the most common reasons for vaccine hesitancy, followed by inadequate knowledge of COVID transmission and lower perceived danger of this disease.[14] Other studies have also shown that female gender, religiosity, and low socioeconomic status may be associated with vaccine hesitancy.[7] In addition, psychological distress may also be associated with a higher level of vaccine hesitancy.[15,16]

Several surveys in Hong Kong have revealed that less than half of the citizens intend to receive the vaccine, while about 30% are hesitant to receive COVID-19 vaccines.[14,17,18] Moreover, the willingness to accept vaccines has decreased as the pandemic progresses.[18] However, these data were collected before vaccination programs were initiated in Hong Kong, and local data on vaccine hesitancy after its initiation are lacking. As of February 2022, 73% of Hong Kong citizens have been fully vaccinated,[19] which is a relatively low figure compared with some other countries, such as Canada (80%), Singapore

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(88%), and Spain (82%).[20] The current vaccination rate in Hong Kong is still insufficient to achieve herd immunity and identifying the factors associated with vaccination hesitancy will help to design specific strategies to address the targeting group's specific concerns.[21,22] Therefore, our study aimed to identify the factors associated with COVID-19 vaccination hesitancy among adults in Hong Kong.

Methods

Procedures and participants

This study was a secondary analysis of vaccine hesitancy of an online cross-sectional survey on sleep in an urban Chinese population during the early stage of the vaccination campaign in Hong Kong. Participants were recruited using convenient sampling via advertising on social media platforms, such as Facebook and Instagram, and instant messaging systems, such as WhatsApp and Signal. Chinese adults with ages over 18 years in Hong Kong capable of comprehending Chinese were invited to participate in this study. They were sent a link to the survey which took approximately 10 mins to complete.

The online survey was conducted between 7 and 21 April 2021 during the early stage of the community-based COVID-19 vaccination campaign by a service platform for administrating online surveys (Qualtrics). The participants were surveyed with a modified questionnaire from our previous internet-based surveys.[23,24] A total of 883 respondents with valid responses to the vaccine status item were included in this study. The participants were informed that they could win prize vouchers of HKD$100 via lottery with a 1 in 50 chance to enhance their response rate.[25] This study was reviewed and approved by the institutional review board of the Hong Kong Polytechnic University (ref: HSEARS20210725001).

Measures

Vaccine hesitancy

The respondents were asked about their recent plans of getting vaccinated with COVID-19 vaccines from their responses of "Be vaccinated/scheduled for vaccination," "Intend to but not in the near future," "Still considering," and "Won't get a vaccine." Similar to previous studies[7,26,27]respondents' levels of vaccine hesitancy were classified as "Without hesitancy," "Low vaccine hesitancy," "High vaccine hesitancy," and "Vaccine rejection" accordingly.

Mental health

The Insomnia Severity Index (ISI) was used to measure the respondents' insomnia symptoms and the associated daytime impairments for two weeks.[28] The respondents were categorized as "having clinical insomnia" and "normal sleepers" by using the suggested optimal cutoff of 10 points of ISI for detecting clinical insomnia in a community sample (sensitivity and specificity: 86.1% and 87.7%, respectively).[29] The mood symptoms of the respondents within the last two weeks were assessed using the Chinese version of the Generalized Anxiety Disorder Assessment (GAD-7)[30,31]and the Patient Health Questionnaire-9 (PHQ-9).[32,33] Scores of at least 10 points in GAD-7 or PHQ-9 indicated the presence of anxiety and depression. A Chinese version of a three-item UCLA Loneliness Scale was adopted to evaluate the feeling of loneliness that the respondents experienced during the period of maintaining social distancing measures.[34] Psychological well-being may be theoretically relevant to vaccine hesitancy.[15,16]

Risk perceptions

The participants' perceived risk of infection in different contexts was assessed by asking them about their worries about themselves or their family members being infected, as well as their worries about infection in the workplace or residential building. Response options included "Not at all," "A bit worried," "Somewhat worried," "Much worried," and "Very much worried." The respondents evaluated their confidence in health professionals and the government's ability to fight against COVID-19 by using five possible responses ranging from "Not at all" to "Very much." This set of items referred to the concept of perceived susceptibility and efficacy, which have been commonly used in the COVID-19 literature regarding health-protective behaviors.[35,36]

COVID-19 exposures and responses

The respondents' media consumption of COVID-19-related content was measured by asking them to indicate the average time they spent browsing the latest information on COVID-19 per day. Response options included "None," "Less than an hour," "An average of 1–2 hours," and "more than 2 hours daily." Those who answered "None" and "Less than an hour" to this item were combined for further analysis. The respondents were also asked whether they had been exposed to COVID-19, for example, being an acute/recovered COVID-19 case or the presence of confirmed cases in their social networks. Their responses to the COVID-19 pandemic were evaluated in three different domains, namely, level of interference with daily living, perceived stress, and economic stress due to the COVID-19 outbreak on a five-point scale ranging from "Not at all" to "Very much stressed/interfered."

Sociodemographic characteristics

The respondents were asked questions on their sociodemographic characteristics, including gender, age, co-residence, and history of chronic physical health conditions.

Statistical analysis

Data were analyzed using R version 4.0.5 (The R Foundation for Statistical Computing). Descriptive statistics were used to describe the respondents' characteristics with mean and standard deviation (SD) for continuous data and number and percentage (%) for categorical data. Scores of ISI, GAD-7, PHQ-9, and UCLA Loneliness Scale were coded into binary data with the prespecified cut point. The respondents were classified as suffering from insomnia, anxiety, depression, and loneliness, respectively. Chi-square test and ANOVA were conducted to explore the distribution of different vaccine hesitancy levels among sociodemographic, clinical, and COVID-19-related characteristics. Variables with a p-value smaller than 0.1 were identified as potential predictors of vaccine hesitancy.

Multinomial logistic regression was computed using the *nnet* package[37]to fit the identified predictors to different levels of vaccine hesitancy. A multinomial logistic model was built to predict low and high vaccine hesitancy and vaccine rejection among adults in Hong Kong with respect to "no vaccine hesitancy" as the reference category of the outcome. Model fit was examined by comparing the final model (with predictors) and the intercept-only null model (without predictors) to determine the model's improvement in predicting vaccine hesitancy. Estimated coefficients of predictors to vaccine hesitancy were exponentiated and expressed in adjusted odds ratio (OR) (aOR) with a 95% confidence interval (CI) and Wald statistic. The overall significance of each predictor in predicting vaccine hesitancy was examined using the likelihood ratio test (LRT). A McFadden pseudo R^2 was estimated and reported in terms of percentage (%) for the variance of vaccine hesitancy as explained by the final model. Statistical significance was set at $p < .05$ for all analyses.

Results

Participants' sociodemographic and clinical characteristics

Tables 1 and 2 provide an overview of the respondents' sociodemographic and clinical characteristics. Of the 883 respondents who provided sufficient data, most of them were well-educated (n = 589, 66.9%) and females (n = 596, 67.5%) with co-residential living arrangement (n = 836, 94.7%). About half of the respondents were married (51.3%), with full-time employment (59.0%), and young adults aged 18–39 years (54.5%). Approximately 80% of the respondents paid little attention to relevant information on COVID-19. On average, the respondents reported that their worry of risking themselves or their family members to infection (mean of 2.43 and 2.74, respectively), and environmental infection (mean of 2.75 and 2.63, respectively), was of mild to moderate severity. However, the respondents had relatively low confidence in the ability of the government to combat COVID-19 (mean = 1.99; SD = 1.08).

Predicting factors of Covid-19 vaccine hesitancy

The sociodemographic and clinical characteristics of the respondents were examined via Chi-square test and ANOVA for potential differences in distributions and mean scores among different levels of vaccine hesitancy (Tables 1 and 2). Factors with a pre-designated significance level of *p*-value <.10 were identified as potential predictors of vaccine hesitancy (Table 3). These factors were further included in the multinomial logistic regression model.

Multinomial logistic regression

Model fit

The model fit between the intercept-only null model and the model with predictors mentioned above was compared. The multinomial logistic regression with predictors demonstrated a more significant reduction of 110.83 in the unexplained variance than the null model (AIC dropped from 2329.81 to 2218.98, df = 63, = 236.83, $p < .001$). The addition of predictors enhanced the ability to explain the variability in vaccine hesitancy. Hence, the model with predictors was preferred.

Table 1. Sociodemographic characteristics of the respondents.

Variable	All samples (n = 883)	No hesitancy (n = 128)	Low hesitancy (n = 270)	High hesitancy (n = 242)	Vaccine rejection (n = 243)	*p*-value ^
Female	596 (67.5)	81 (63.3)	173 (64.1)	165 (68.2)	177 (72.8)	.13
Age						<.001
18–39 years	481 (54.5)	48 (37.5)	122 (45.2)	138 (57.0)	173 (71.2)	
40–59 years	284 (32.2)	53 (41.4)	93 (34.4)	79 (32.6)	59 (24.3)	
≥60 years	118 (13.4)	27 (21.1)	55 (20.4)	25 (10.3)	11 (4.5)	
Marital status						<.001
Single	385 (43.6)	34 (26.6)	88 (32.6)	115 (47.5)	148 (60.9)	
Separated/Divorced/Widowed	45 (5.1)	3 (2.3)	16 (5.9)	10 (4.1)	16 (6.6)	
Married/Cohabitated	453 (51.3)	91 (71.1)	166 (61.5)	117 (48.4)	79 (32.5)	
Child caring burden (youngest child in household)						.27
Kindergarten	48 (5.4)	3 (2.3)	21 (7.8)	14 (5.8)	10 (4.1)	
Primary school	57 (6.5)	12 (9.4)	14 (5.2)	17 (7.0)	14 (5.8)	
Secondary school	96 (10.9)	14 (10.9)	31 (11.5)	30 (12.4)	21 (8.6)	
No child rearing/adults	682 (77.2)	99 (77.3)	204 (75.6)	181 (74.8)	198 (81.5)	
Co-residence	836 (94.7)	123 (96.1)	255 (94.4)	230 (95.0)	228 (93.8)	.81
Educational attainment (n = 881)						.39
Junior form of Secondary school or below	29 (3.3)	4 (3.1)	9 (3.4)	8 (3.3)	8 (3.3)	
Senior form of Secondary school	263 (29.9)	36 (28.1)	93 (34.7)	60 (24.8)	74 (30.5)	
Tertiary education	589 (66.9)	88 (68.8)	166 (61.9)	174 (71.9)	161 (66.3)	
Employment status						.08
Employed	521 (59.0)	87 (68.0)	154 (57.0)	152 (62.8)	128 (52.7)	
Unemployed	27 (3.1)	4 (3.1)	7 (2.6)	6 (2.5)	10 (4.1)	
Economically inactive	335 (37.9)	37 (28.9)	109 (40.4)	84 (34.7)	105 (43.2)	
With chronic disease	127 (14.4)	22 (17.2)	49 (18.2)	31 (12.8)	25 (10.3)	.05
With regular exercise#	386 (42.9)	61 (47.7)	125 (46.3)	103 (42.6)	97 (39.9)	.38
At least monthly exposure to nature	283 (32.1)	49 (38.3)	102 (37.8)	75 (31.0)	57 (23.5)	.002

Note: Data presented as number (percentage).
^ Group comparisons were made using Chi-square test.
#Regular exercise was defined as having at least three days of moderate or vigorous physical activities in a week.

Table 2. Clinical characteristics and COVID-19 responses of the respondents.

Variable	All samples (n = 883)	No hesitancy (n = 128)	Low hesitancy (n = 270)	High hesitancy (n = 242)	Vaccine rejection (n = 243)	*p*-value ^
Time spent on browsing COVID-19 information						.37
Less than an hour per day	730 (82.7)	106 (82.8)	229 (84.8)	200 (82.6)	195 (80.3)	
1–2 hours per day	108 (12.2)	19 (14.8)	28 (10.4)	31 (12.8)	30 (12.4)	
More than 2 hours per day	45 (5.1)	3 (2.3)	13 (4.8)	11 (4.6)	18 (7.4)	
Exposure to COVID-19 virus	335 (37.9)	46 (35.9)	94 (34.8)	106 (43.8)	89 (36.6)	.17
Mental health[#]						
ISI score, 0–28	7.9 ± 5.6	7.3 ± 5.6	7.1 ± 5.0	7.8 ± 5.6	9.3 ± 5.9	<.001
Clinical insomnia, ISI score ≥10	287 (32.5)	42 (32.8)	70 (25.9)	76 (31.4)	99 (40.7)	.005
GAD-7 score, 0–21	4.9 ± 5.2	4.2 ± 4.7	4.0 ± 4.1	5.1 ± 5.4	6.1 ± 5.9	<.001
Clinical anxiety, GAD-7 score ≥10	144 (16.3)	17 (13.3)	26 (9.6)	43 (17.8)	58 (23.9)	<.001
PHQ-9 score, 0–27	6.0 ± 5.4	5.0 ± 5.0	4.9 ± 4.2	5.9 ± 5.4	7.8 ± 6.4	<.001
Clinical Depression, PHQ-9 score ≥10	176 (19.9)	22 (17.2)	29 (10.7)	51 (21.1)	74 (30.5)	<.001
UCLA loneliness score, 0–9	2.7 ± 2.7	2.4 ± 2.5	2.5 ± 2.5	2.6 ± 2.6	3.4 ± 2.8	<.001
Loneliness, UCLA loneliness score ≥3	444 (50.3)	54 (42.2)	127 (47.0)	113 (46.7)	150 (61.7)	<.001
COVID-19 responses						
Interference to daily living¶	3.0 ± 1.1	2.9 ± 1.1	2.8 ± 1.0	3.0 ± 1.1	3.1 ± 1.1	.06
Perceived stress¶	2.5 ± 1.1	2.4 ± 1.0	2.4 ± 1.0	2.6 ± 1.1	2.8 ± 1.1	<.001
Financial pressure ¶	2.0 ± 1.1	2.0 ± 1.2	1.8 ± 1.0	2.0 ± 1.1	2.3 ± 1.3	<.001
Worry about being infected (n = 881)Ω	2.4 ± 1.0	2.3 ± 1.0	2.3 ± 0.9	2.6 ± 0.9	2.5 ± 1.1	.01
Worry about family members being infected (n = 866)Ω	2.7 ± 1.1	2.7 ± 1.0	2.6 ± 1.1	2.9 ± 1.0	2.8 ± 1.2	.02
Worry about workplace infection (n = 878)Ω	2.8 ± 1.1	2.5 ± 1.0	2.7 ± 1.1	2.9 ± 1.0	2.9 ± 1.3	<.001
Worry about infection in residential buildings (n = 877)Ω	2.6 ± 1.1	2.4 ± 0.9	2.5 ± 1.0	2.7 ± 1.0	2.8 ± 1.2	<.001
Confidence in health professionals[ᵕ]	3.1 ± 1.0	3.2 ± 1.0	3.2 ± 1.0	3.0 ± 1.0	3.0 ± 1.0	.09
Confidence in the government[ᵕ]	2.0 ± 1.1	2.5 ± 1.2	2.3 ± 1.2	1.9 ± 1.0	1.5 ± 0.8	<.001

Abbreviations: COVID-19, Coronavirus Disease 2019; ISI, Insomnia Severity Index; GAD-7, Generalized Anxiety Disorder Assessment; PHQ-9, Patient Health Questionnaire-9.
Data presented as number (percentage) or mean±standard deviation.
^ Group comparisons were made using Chi-square test or ANOVA.
[#]Higher scores indicated poorer sleep/mood symptoms.
[¶]Higher scores indicated greater disturbance due to COVID-19.
Ω Higher scores indicated greater worry.
[ᵕ] Higher scores indicated higher confidence in the perceived ability against COVID-19.

Table 3. Likelihood ratio test of the main effect of each predictor included in this study.

Variables	*p*-value
Age	.001
Marital status	<.001
Employment status	.10
Chronic disease	.87
Exposure to nature	.22
Clinical insomnia	.56
Clinical anxiety	.72
Clinical depression	.25
Loneliness	.11
Daily interference	.26
Perceived stress	.68
Financial pressure	.06
Worry about self	.28
Worry about family members	.43
Worry of workplace infection	.23
Worry of residential building infection	.32
Confidence in health professionals	.82
Confidence in government	<.001

Predictors' significance and pseudo R2

The likelihood statistics presented in Table 3 illustrate the contribution of each predictor to the performance of the whole model in predicting the levels of vaccine hesitancy with LRT. In the current model, only the age and marital status of the respondents and their confidence in government were confirmed to have significant main effects on predicting vaccine hesitancy (all $p < .01$). About 10%–26% of the variance of individual differences in vaccine hesitancy was explained by the current model with predictors (Cox Snell's $R^2 = 0.24$; Nagelkerke's $R^2 = 0.26$; McFadden's $R^2 = 0.10$).

Parameter estimations

Table 3 lists the variables included in the multinomial logistic analysis, and their specific effects on predicting vaccines are presented while holding other predictors constant. Within the current model, being employed full time (versus economically inactive: $aOR = 0.46$ [95% CI = 0.26–0.82], $p = .009$) and greater worry of workplace infection ($aOR = 1.45$ [95% CI = 1.00–2.11], $p = .049$) were significant predictors of low vaccine hesitancy with respect to no vaccine hesitancy.

Among the respondents with high vaccine hesitancy, the significant predictors were as follows. Young adults ($aOR = 2.99$ [95% CI = 1.23–7.30], $p = .02$) and middle-aged adults ($aOR = 2.99$ [95% CI = 1.07–5.47], $p = .03$) were associated with a 2.99-fold increase in odds of high vaccine hesitancy compared with the elderly. Married individuals were less likely to have high vaccine hesitancy compared with single individuals ($aOR = 0.51$ [95% CI = 0.29–0.88], $p = .02$). People with a full-time job were less likely to have high vaccine hesitancy ($aOR = 0.55$ [95% CI = 0.30–0.99], $p = .045$). Moreover, those with high confidence in the ability of the government to fight COVID-19 were unlikely to have high vaccine hesitancy ($aOR = 0.68$ [95% CI = 0.54–0.86], $p = .001$).

The results shown in Table 4 were consistent with high vaccine hesitancy but had greater effect sizes in predicting vaccine rejection. Young adults and middle-aged adults ($aOR = 11.00$ [95% CI = 3.64–33.24], $p < .001$) had a higher probability of vaccine rejection compared with adults aged ≥60 years ($aOR = 7.02$ [95% CI = 2.48–19.83], $p < .001$). By contrast, being married was associated with a lower odds of vaccine rejection versus being single ($aOR = 0.37$ [95% CI = 0.21–0.65], $p = .001$). Meanwhile, those with full-time employment

Table 4. Multinomial logistic regression for vaccine hesitancy (n = 858)[#].

Variable, N (%)	Low vaccine hesitancy			High vaccine hesitancy			Vaccine rejection		
	aOR	95% CI	Wald	aOR	95% CI	Wald	aOR	95% CI	Wald
Intercept	3.53	0.76, 16.53	1.60	4.41	0.91, 21.37	1.84	5.81*	1.02, 33.20	1.98
Age									
18–39 years	2.1	0.91, 4.81	1.75	2.99*	1.23, 7.30	2.41	11***	3.64, 33.24	4.25
40–59 years	1.58	0.75, 3.34	1.21	2.42*	1.07, 5.47	2.12	7.02***	2.48, 19.83	3.68
≥60 years (reference group)									
Marital status									
Married/cohabitated	0.73	0.42, 1.29	−1.09	0.51*	0.29, 0.88	−2.39	0.37**	0.21, 0.65	−3.40
Divorced/separated/widowed	2.28	0.55, 9.49	1.14	1.54	0.35, 6.83	0.57	3.87	0.87, 17.14	1.78
Never married (reference group)									
Employment status									
Employed (full time)	0.46**	0.26, 0.82	−2.63	0.55*	0.30, 0.99	−2.00	0.41**	0.22, 0.75	−2.89
Unemployed	0.65	0.16, 2.70	−0.59	0.59	0.14, 2.48	−0.71	0.81	0.20, 3.24	−0.30
Economically inactive (reference group)									
Chronic physical health condition									
Yes	1.21	0.64, 2.29	0.59	1.11	0.56, 2.18	0.30	1.35	0.64, 2.86	0.78
No (reference group)									
At least monthly exposure to nature									
Yes	0.98	0.62, 1.56	−0.09	0.80	0.49, 1.29	−0.93	0.64	0.38, 1.08	−1.68
No (reference group)									
Clinical Insomnia									
Yes	0.77	0.42, 1.40	−0.85	0.81	0.44, 1.50	−0.67	1.07	0.56, 2.01	0.20
No (reference group)									
Clinical anxiety									
Yes	0.61	0.24, 1.55	−1.03	0.87	0.36, 2.09	−0.31	0.77	0.32, 1.88	−0.57
No (reference group)									
Clinical depression									
Yes	0.66	0.28, 1.57	−0.94	1.07	0.47, 2.47	0.17	1.35	0.58, 3.13	0.70
No (reference group)									
Loneliness									
Yes	1.5	0.88, 2.55	1.49	0.98	0.57, 1.69	−0.08	1.49	0.84, 2.64	1.37
No (reference group)									
Interference to daily living	0.95	0.72, 1.25	−0.36	0.86	0.65, 1.13	−1.06	0.78	0.58, 1.04	−1.71
Perceived stress	1.01	0.74, 1.38	0.09	1.03	0.76, 1.41	0.21	0.89	0.64, 1.23	−0.70
Financial pressure	0.8	0.62, 1.03	−1.76	0.83	0.65, 1.06	−1.48	1.01	0.78, 1.30	0.06
Worry about being infected	0.92	0.64, 1.33	−0.42	1.14	0.79, 1.65	0.07	0.87	0.59, 1.27	−0.73
Worry about family members being infected	0.78	0.55, 1.10	−1.41	0.79	0.56, 1.12	−1.34	0.75	0.52, 1.06	−1.62
Worry about workplace infection	1.45*	1.00, 2.11	1.97	1.31	0.90, 1.91	1.41	1.21	0.82, 1.79	0.97
Worry about infection in residential building	1.1	0.75, 1.61	0.50	1.19	0.81, 1.74	0.89	1.39	0.94, 2.07	1.66
Confidence in health professionals	1.08	0.84, 1.39	0.58	1.00	0.77, 1.28	−0.03	1.07	0.82, 1.39	0.51
Confidence in government	0.83	0.66, 1.04	−1.60	0.68**	0.54, 0.86	−3.18	0.43***	0.33, 0.56	−6.26

Abbreviations: aOR, Adjusted Odds Ratio; CI, Confidence Interval.
[#]"No vaccine hesitancy" was used as the reference category of outcome.
* $p < .05$, ** $p < .01$, *** $p < .001$.

were 0.41-fold (95% CI = 0.22–0.75, $p = .004$) less likely to reject vaccination than those were economically inactive. Furthermore, individuals were 0.43-fold less likely to reject vaccination up to every unit of increase in confidence in the government to combat COVID-19 (95% CI = 0.33–0.56, $p < .001$).

Discussion

In the current study, we aimed to identify the factors associated with COVID-19 vaccines hesitancy among residents of Hong Kong during the early phase of the vaccine campaign. Approximately 14.5% of the respondents had received at least one dose of COVID-19 vaccines or expressed willingness to accept COVID-19 vaccines; 58.0% and 27.5% were regarded as vaccine-hesitant and vaccine-resistant, respectively. Young adults were associated with an increased likelihood of vaccine hesitancy and resistance, whereas those who were married, had full-time employment, and had high confidence in the government were less likely to become vaccine-hesitant and reject vaccination. The results provided insights for researchers and policymakers that can be employed in the formulation of specific strategies to target those people with such characteristics because they may have a high risk of vaccine hesitancy and resistance.

In line with previous studies, our results showed that young adults and those who lacked confidence in the government were associated with an increased likelihood of vaccine hesitancy or resistance.[7,16,38] It was evidenced by the relatively low vaccine coverage in younger generations in Hong Kong during the study period (17.7% fully vaccinated)[27,39]while the vaccine program had expanded to over 80% of the population aged 16 or above. The vaccine coverage started to boost until the COVID-19 vaccine lottery was available in June 2021. As of February 2022 or almost one year after the vaccine campaign was launched, 82.47%% of Hong Kong adult citizens have been fully vaccinated (i.e., received a two-dose vaccine).[19,27] Despite the enforcement of mandatory vaccinations for some key work sectors (e.g., teachers, healthcare workers) and for entering on-listed venues (including hospitals), a certain number of citizens

still rejected the vaccine. In addition to these relatively well-researched factors, our results also identified that individuals with a full-time job and married were less likely to become vaccine-hesitant or resistant. Having a full-time job was associated with a higher likelihood of receiving vaccines, compared to those who were economically inactive. A possible explanation is that they perceived that they would have a greater chance of being infected because Hong Kong is a highly dense urban city and their risk of being infected during their time in public transport and at the workplace is high. Therefore, they have a stronger incentive to receive the vaccination. Furthermore, being married was associated with less likelihood of vaccine hesitance and resistance. Such a finding was rarely mentioned by previous studies conducted in Western countries. This result could be attributed to the importance of family and collectivism promoted in Confucianism and the Chinese culture.[40] Chinese people have a strong sense of responsibility toward their families, and they probably hold the view that being vaccinated is an action they can do to protect their families. Moreover, emerging studies yielded mixed results on the effects of mental health on vaccine hesitancy[15,16,27,41,42]although no significant association was found between current mental health status (depression, anxiety, and insomnia) and vaccine hesitancy in this study.

This study found that the lack of trust or confidence in the government was related to increased vaccine hesitancy or resistance, which is consistent with the findings of previous studies.[7,16] Although protection of vaccines might be restricted because of the rapid evolvement of COVID-19 variants (e.g., Delta, Omicron), it is the most efficacious option available to date.[43] To facilitate mass vaccination, government authorities have to earn the public's confidence before enforcing vaccine pass arrangements. However, instantly boosting the public's confidence in the government and the authorities may be difficult. Those who lack trust in the government or health service system are more sensitive to misinformation about vaccines.[44] It is consistent with the observation of widespread rumors on adverse events of vaccines and anti-vaccine discussions in social forums. The government should take preemptive actions, such as cognitive inoculation techniques,[27] to debunk vaccine misinformation regarding vaccine efficacy and safety before the implementation of the vaccine pass. The emphasis on vaccination, which is mainly a public health concern without political reasons, deserves more effort in the current Hong Kong situation.

A fully vaccinated population is still considered imperative to mitigate the effects of the pandemic because of the reduced risks of infection and death.[43] Because the vaccination rate of specific age groups is still low in Hong Kong (e.g., only 63.84% in individuals aged 60 years or above)[2,19]more effort is needed to raise vaccine acceptance through effective means of public communications. With reference to literature on vaccine hesitancy, policymakers should facilitate more effective risk communication with sufficient elucidation of empirical data on full vaccination. Given that group-specific message has a positive effect on promoting vaccine uptake,[21,22] addressing specific barriers to COVID-19 vaccines among vaccine-hesitant individuals in Hong Kong must be determined. As younger age and distrust in government were found as factors for vaccine hesitancy in our study, the government should investigate the reasons behind refusing vaccines in these groups. While time may be necessary to build trust in government, the government may deploy renowned opinion leaders in the society to disseminate the message of promoting vaccination and clarify the misinformation.

This study has several limitations. One major limitation is that this survey was based on an online survey and disseminated over the internet via social media but not by random sampling. Thus, the online questionnaire would be less likely to reach those who did not have internet access (e.g., the old, the poor) and the sample cannot be considered a representative sample of the Hong Kong population. Thus, the sample was not representative of the residents of Hong Kong, thereby limiting the generalization of the results to other populations. In addition, this study did not include questions on specific behaviors and attitudes related to COVID-19 vaccination, such as their knowledge of the science of vaccines or conspiracy beliefs. These attitudes and beliefs are mildly associated with vaccine hesitancy.[11–13]Further studies may explore these vaccine-related beliefs. Finally, the respondents' vaccination status was primarily self-reported, and thus, the results might have been prone to response bias.

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