BMJ Open

Factors influencing COVID-19 vaccination uptake: a cross-sectional online survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-058416
Article Type:	Original research
Date Submitted by the Author:	15-Oct-2021
Complete List of Authors:	Wong, Cho Lee; The Chinese University of Hong Kong The Nethersole School of Nursing Leung, Alice; The Chinese University of Hong Kong The Nethersole School of Nursing Chung, Oscar ; The Chinese University of Hong Kong The Nethersole School of Nursing Chien, Wai-Tong; The Chinese University of Hong Kong The Nethersole School of Nursing
Keywords:	COVID-19, Epidemiology < TROPICAL MEDICINE, INFECTIOUS DISEASES

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Factors influencing COVID-19 vaccination uptake: a cross-sectional online survey

Cho Lee Wong, Alice Wai Yi Leung, Oscar Man Hon Chung, Wai Tong Chien*

The Nethersole School of Nursing, Faculty of Medicine, The Chinese University of Hong, Hong Kong

***Corresponding author:**
Wai Tong Chien
Director and Professor
The Nethersole School of Nursing, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong
Tel: (852) 3943 8172;
E-mail: wtchien@cuhk.edu.hk

Contact information of first author
Cho Lee Wong
Assistant Professor
The Nethersole School of Nursing, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong
Tel: (852) 3943 8166;
E-mail: jojowong@cuhk.edu.hk

Word Count: 3003

ABSTRACT

Introduction Vaccination is recognised to be the most effective approach to contain the spread of the COVID-19 pandemic in a long run. However, the global vaccination uptake is still suboptimal. Although a considerable number of studies have focused on factors influencing intention or acceptance of COVID-19 vaccination, few explore the factors that affect actual vaccination uptake. This study aimed to explore the factors that influence COVID-19 vaccination uptake among the general public in a developed country.

Methods A cross-sectional online survey was conducted between June and August 2021. Community members were recruited through convenient and snowball sampling to complete an anonymous online survey. The survey assessed respondents' sociodemographic characteristics, vaccination status and perceived impact of COVID-19, as well as their attitudes towards COVID-19.

Results A total of 358 valid questionnaires were received. The results showed that 50.8% of the participants received two doses of the vaccine. Multivariable logistic regression analysis suggested that the participants' vaccination uptake was associated with their jobs affected by COVID-19, had an income source, perceived good/excellent physical health status, perceived COVID-19 exposure, perceived good/excellent knowledge of COVID-19, learned about the vaccine from printed materials and perceived that their family members were at risk of contracting COVID-19.

Conclusion This is one of the first few cross-sectional studies that explored factors associated with the actual vaccination uptake of the general public during the COVID-19 pandemic. The results can provide insights for formulating strategies to increase COVID-19 vaccination rates in developed countries.

Keywords: vaccination uptake, factors, COVID-19

Strengths and limitations of this study

- This is one of the first few cross-sectional studies that explored factors associated with the actual vaccination uptake of the general public during the COVID-19 pandemic**.**
- The results can provide insights for formulating strategies to increase COVID-19 vaccination rates in developed countries.
- This study adopted a cross-sectional design so that the causality cannot be ascertained.
- This non-random sample was over-represented by female, highly educated and younger adults.
- The use of self-report questionnaires might also be subject to social desirability bias and inaccurate understanding and responses to the questionnaire.

INTRODUCTION

Shortly after the outbreak of Coronavirus disease 2019 (COVID-19) in China around December 2019, the infection quickly spread across the globe and caused disturbances in many aspects of life. As of August 31, 2021, more than 217 million infected cases and more than 4.5 million deaths have been recorded worldwide[1]. At the same time, Hong Kong has experienced four waves of COVID-19 infection, with confirmed cases and deaths stagnating at around 12,000 and 200, respectively[2].

In order to contain the spread of the pandemic, governments around the world have adopted measures such as social distancing and border control. These measures imposed considerable restrictions on individuals and caused heavy health and economic losses[3,4]. Alternatively, achieving herd immunity against COVID-19 through vaccinations is considered to be the most effective means to contain the spread of the pandemic in a long run[5,6].

As of August 31, 2021, only 27.1% of the global population has been fully vaccinated [1]. The current vaccination rate in most countries is far below the target group herd immunity thresholds (15.3%-77.1%)[7]. Due to the ample supply of vaccines in high- and upper-middle income countries, the suboptimal COVID-19 vaccination rate in most of these countries indicate that vaccine hesitancy is prevalent. The World Health Organization defines vaccine hesitancy as "the delay in acceptance or refusal of vaccination despite availability of vaccination services"[8], and listed it as one of the 10 top/major threats to global health in 2019[9].

In Hong Kong, the government has launched a territory-wide vaccination programme on February 26, 2021, providing all Hong Kong residents with free CoronaVac (Sinovac) inactivated vaccine and the Comirnaty (BioNTech) mRNA vaccine[10]. The vaccination progress had been slow until a sudden surge was observed in mid-June (7-day moving average of total doses administered >40,000[10]), which might attributable to the government's "Early Vaccination for All" campaign, which features the facilitation and reward strategies for

vaccinated people (for example, vaccination leave and relaxation of social distancing)[11]. In addition, the business sector also held a number of lucky draws (for example, a first prize of a HK$ 7 million-dollar flat, HK$ 1 million dollars) to boost the COVID-19 vaccination rate. However, the current vaccination rate in Hong Kong (around 50% at the end of August) is still far from reaching the target of at least 70% of the eligible population[12]. The suboptimal vaccination rates call for more effective strategies to overcome barriers, not just merely provide incentives.

Emerging epidemiological evidence suggests a broad array of factors that affect the intention to vaccinate against COVID-19 among the general public, including sociodemographic factors such as age[13-15] and employment status[13,14]; disease-specific factors such as risk perception[15-17] and COVID-19 information exposure[14-18]; and vaccine-specific factors such as confidence in efficacy and safety[13-15,17,19] and vaccination attitudes[15,20]. However, the major factors influencing actual vaccine uptake have seldom been explored. A recent cross-sectional study on 1,037 older Germans suggested that general health condition, the presence of chronic conditions, perceptions of infection, the severity of potential long-term effects, the efficacy of vaccines, the benefits of vaccination, the negative side-effects of vaccines and the general impediments to vaccination were the determinants of actual vaccination[17].

After the launch of the territory-wide vaccination programme in Hong Kong, a few population-based surveys have explored the factors that influence vaccination uptake. These surveys reported a vaccine hesitancy rate of 27.6-44.6%[21,22]. The major reasons for vaccine hesitancy included physically unfit for vaccination due to medical reasons [21] and worried about serious side effects of vaccines[21,22]. In a telephone survey on Hong Kong citizens' attitudes and opinions on vaccination, respondents who had received the vaccine had significantly higher rating on the Government's anti-epidemic efforts than those who had not been vaccinated[22].

Existing studies on vaccination intentions are largely conducted prior to the commencement of the worldwide mass vaccination programmes. With the further advancement of vaccine technology and the rapid emergence of COVID-19 variants, the factors that predict the actual vaccine uptake have yet to be determined. In this context, there is an urgent need to conduct more studies to investigate the factors of actual vaccination uptake to inform the current and future measures to promote vaccination uptake in Hong Kong and other developed countries. Therefore, this study aimed to explore the factors that affect COVID-19 vaccine uptake among general populations in Hong Kong.

METHODS

Study design

This study adopted a cross-sectional design using an online survey.

Setting and sample

Participants were recruited online from June to August 2021. Eligible participants were community members (1) aged 18 or above; (2) able to understand the instructions and items of the questionnaire in either Chinese or English; and (3) given written consent (by answering 'yes' on the first page of the survey). Participants who self-disclosed that they had major depressive disorder, cognitive impairment, or illiteracy were excluded.

The sample size was determined to allow adequate precision to estimate the COVID-19 vaccination rate. By using the power analysis software, PASS 16.0 (NCSS, Kaysville, US), it was estimated that a sample size of n=340 participants would allow the study to estimate the uptake rate with a margin of error of at most ±5% at a level of significance of 0.05 on the basis of an anticipated uptake rate of around one-third.

For the online surveys, an online survey portal was created using SurveyMonkey, a secure cloud-based online survey platform. A brief study description, consent form, and the questionnaires were included in the online survey portal. Participants were invited to participate in the study through the social messaging mobile application WhatsApp, where a link was rolled out through various WhatsApp groups from staff working in a local university. Participants were recruited through convenient and snowball sampling. All respondents were asked to forward the link to their family and friends. Potential participants responded to the invitation by clicking a link that direct them to the online survey portal; and they were asked to click the "yes" button on the first page of study information and instructions to indicate their consent to participate. After consented given, they would complete a set of self-developed questionnaire online, lasting about 8-10 minutes.

Survey Instrument

A set of questionnaires comprised three sections was developed by the research team with references to previous studies of similar topics[14,16,23], and the current recommendations and guidelines from health authorities. The questionnaire was reviewed by a panel of experts and was validated with 20 community members for their understanding of the questionnaire content before actual use. The questionnaire consisted of three sections:

1. Participants' socio-demographic characteristics, health conditions and lifestyle characteristics, including age, gender, place of birth, living status, marital status, highest educational qualification, current employment condition, co-morbidities, smoking and alcohol drinking status, perceived physical and mental health status.
2. Vaccination status and perceived impact of COVID-19: uptake of COVID-19 vaccination (yes/no), reasons for/against vaccination (an open-ended question), impact of COVID-19 on financial situation, contact with known/suspected cases of COVID-19, perceived COVID-

19 exposure, perceived knowledge of COVID-19 and COVID-19 vaccines, sources of information about COVID-19 and COVID-19 vaccines, healthcare service used to overcome COVID-19 related stress in the past six months.

3. Attitudes towards COVID-19: a 10-item questionnaire developed by the research team[23]. The questionnaire comprises two subscales: perceived risk of COVID-19 (7 items) and perceived self-efficacy in controlling COVID-19 (3 items). Each item was rated on a 5-point Likert scale (from 1='strongly disagree' to 5='strongly agree'. Internal consistency of the scale was satisfactory (Cronbach's alpha=0.71).

Statistical analysis

The participant's characteristics, including socio-demographics, health conditions and lifestyle characteristics, and experience or perceptions related to COVID-19, perceived risk of COVID-19 and perceived self-efficacy in controlling COVID-19 were categorized and presented using frequency and percentage. These characteristics were compared between the participants who had vaccinated (at least one dose) and those who had not, using Pearson's chi-square test. Those characteristics with $p<0.25$ in univariate analyses were selected as candidate independent variables for a backward multivariable logistic regression analysis to delineate factors significantly and independently associated with their vaccination status. All statistical analyses were performed using IBM SPSS 25.0 (IBM Crop, Armonk, NY) and the level of significance set at 0.05 (two-sided).

Ethical considerations

Ethical approval was obtained from Survey and Behavioural Research Committee of The Chinese University of Hong Kong (SBRE-20-784). All study procedures involving human subjects was handled in accordance with the Helsinki Declaration. The participants were

assured that their participation was voluntary, their rights to withdraw at any time was upheld, and their information was confidential.

RESULTS

Sample characteristics

A total of 384 community members consented via online and participated in the study. Twenty-six respondents were excluded from the analyses due to having missing data on more than 30% of the questionnaire items. Hence, the final sample were 358 participants (i.e., completion rate=93.2%). The mean age of the participants was 38.27 (SD=14.79), and 69.0% were female. Table 1 shows a summary of the socio-demographic characteristics, health conditions and lifestyle characteristics of the participants.

Table 1. Characteristics of the study sample (N=358).

	All (N=358)	Vaccinated against COVID-19		p-value #
		No (n=115)	Yes (n=243)	
Socio-demographic characteristics				
Age (years)				
18 – 29	127 (35.5%)	42 (36.5%)	85 (35.0%)	0.254
30 – 59	202 (56.4%)	60 (52.2%)	142 (58.4%)	
≥ 60	29 (8.1%)	13 (11.3%)	16 (6.6%)	
Gender				
Female	247 (69.0%)	85 (73.9%)	162 (66.7%)	0.166
Male	111 (31.0%)	30 (26.1%)	81 (33.3%)	
Birth in Hong Kong				
No	48 (13.4%)	13 (11.3%)	35 (14.4%)	0.422
Yes	310 (86.6%)	102 (88.7%)	208 (85.6%)	
Living status				
Live without family members	34 (9.5%)	8 (7.0%)	26 (10.7%)	0.259
Live with family members	324 (90.5%)	107 (93.0%)	217 (89.3%)	
Marital status				
Single/ divorced/ widowed	194 (54.2%)	60 (52.2%)	134 (55.1%)	0.598
Cohabiting/ married	164 (45.8%)	55 (47.8%)	109 (44.9%)	
Highest educational qualification				
Secondary/ higher secondary/ grade 7 to 12 or below	76 (21.2%)	32 (27.8%)	44 (18.1%)	0.055
Certificate/Diploma/Trade qualifications	40 (11.2%)	15 (13.0%)	25 (10.3%)	
Bachelor/Masters/PhD	242 (67.6%)	68 (59.1%)	174 (71.6%)	
Current employment condition				
Unemployed/home maker (no source of income)	102 (28.5%)	49 (42.6%)	53 (21.8%)	<0.001
Jobs affected by COVID-19	19 (5.3%)	6 (5.2%)	13 (5.3%)	
Have an income source	237 (66.2%)	60 (52.2%)	177 (72.8%)	
Health conditions and lifestyle characteristics				
Chronic medical conditions				
No	316 (88.3%)	98 (85.2%)	218 (89.7%)	0.217

Yes	42 (11.7%)	17 (14.8%)	25 (10.3%)	
Smoking status				
Never smoker	329 (91.9%)	102 (88.7%)	227 (93.4%)	0.126
Ever smoker	29 (8.1%)	13 (11.3%)	16 (6.6%)	
Current alcohol drinking (in the last 4 weeks)				
No	197 (55.0%)	57 (49.6%)	140 (57.6%)	0.153
Yes	161 (45.0%)	58 (50.4%)	103 (42.4%)	
Perceived physical health status				
Poor/ fair	25 (7.0%)	14 (12.2%)	11 (4.5%)	<0.001
Average	165 (46.1%)	65 (56.5%)	100 (41.2%)	
Good / excellent	168 (46.9%)	36 (31.3%)	132 (54.3%)	
Perceived mental health status				
Poor/ fair	34 (9.5%)	18 (15.7%)	16 (6.6%)	<0.001
Average	152 (42.5%)	62 (53.9%)	90 (37.0%)	
Good / excellent	172 (48.0%)	35 (30.4%)	137 (56.4%)	

Data are presented as frequency (%).
[#]All the p values were computed based on Pearson chi-square test.

Uptake of COVID-19 vaccination and reasons

Overall, 67.8% (243/358) of the participants had received at least one dose of COVID-19 vaccine and, among those vaccinated, 74.9% (182/243) had received two doses. Table 2 summarises the main reasons for vaccination; and the most commonly reported reasons were "desire to protect self" (70.0%) and "desire to protect friends/family" (60.9%). Among those not vaccinated, over half of them (51. 4%) reported low intention (scored 0-3) to get vaccinated in the following 15 days. The most commonly cited reason for their hesitancy was their "concern about the side effects and safety of the vaccine" (60.0%), followed by "plan to wait and see if it is safe and may get it later" (51.3%) (see Table 2).

Table 2. Reasons for vaccine uptake and hesitancy

Reasons for getting vaccinated against COVID-19* (N=243)	**n (%)**
Desire to help flatten the curve of disease	123 (50.6)
Desire to protect self	170 (70.0)
Desire to protect friends/ family	148 (60.9)
Desire to travel aboard	101 (41.6)
Compulsory in the workplace	57 (23.5)
Others (Worry about availability of vaccines in the future, study-related requirements, visit elderly homes)	12 (4.9)
Reasons for not getting vaccinated against COVID-19* (N=115)	**n (%)**
Concern about the side effects and safety of the vaccine	69 (60.0)
The vaccine is being developed too quickly	32 (27.8)
Plan to wait and see if it is safe and may get it later	59 (51.3)

Doctor did not recommend me for COVID-19 vaccination	9 (7.8)
The vaccine will not work	11 (9.6)
Don't like needles	11 (9.6)
Others (chronic disease, pregnant, not understand self-health, after surgery, allergy, planning)	16 (4.5)

* multiple responses possible

Other information concerning COVID-19 impacts and vaccinations

Table 3 summarises the information concerning COVID-19 impacts and vaccinations. Majority of them (78.2%) perceived the pandemic did not have impact on their financial situation. Only 7% of them had known or suspected contact(s) with COVID-19 cases, but nearly one-fifth (22.6%) perceived they had exposed to COVID-19; and 16.4% of them had a consultation due to COVID-19 related stress in last 6 months. About one-third of the participants perceived that they had good or excellent knowledge about COVID-19 (36.6%) and/or COVID-19 vaccines (34.3%); of which, their sources of knowledge were from the Internet (70.7% and 69.8%, respectively) and/or TV (69.8% and 62.8%, respectively).

Table 3. Information concerning COVID-19 impacts and vaccinations.

	Total (N=358)	Vaccinated against COVID-19		p-value#
		No (n =115)	Yes (n =243)	
Experience or perceptions related to COVID-19				
COVID-19 impacted financial situation	280 (78.2%)	85 (73.9%)	195 (80.2%)	0.131
No impact	17 (4.7%)	4 (3.5%)	13 (5.3%)	
Yes, impacted positively	61 (17.0%)	26 (22.6%)	35 (14.4%)	
Yes, impacted negatively				
Contact with known/suspected case of COVID-19	302 (84.4%)	105 (91.3%)	197 (81.1%)	0.017
No	25 (7.0%)	2 (1.7%)	23 (9.5%)	
Yes	31 (8.7%)	8 (7.0%)	23 (9.5%)	
Unsure				
Perceived exposure to COVID-19				
No	277 (77.4%)	100 (87.0%)	177 (72.8%)	0.003
Yes	81 (22.6%)	15 (13.0%)	66 (27.2%)	
Had ever used any healthcare service to overcome COVID-19 related stress in the last 6 months				
No	303 (84.6%)	94 (81.7%)	209 (86.0%)	0.296
Yes	55 (15.4%)	21 (18.3%)	34 (14.0%)	
Perceived knowledge of COVID-19				

Poor/ fair	20 (5.7%)	10 (9.3%)	10 (4.1%)	<0.001
Average	202 (57.7%)	76 (71.0%)	126 (51.9%)	
Good / excellent	128 (36.6%)	21 (19.6%)	107 (44.0%)	
Perceived knowledge of COVID-19 vaccine				
Poor/ fair	33 (9.4%)	14 (13.1%)	19 (7.8%)	<0.001
Average	197 (56.3%)	75 (70.1%)	122 (50.2%)	
Good / excellent	120 (34.3%)	18 (16.8%)	102 (42.0%)	
Reported sources of knowledge about COVID-19*				
Newspapers and magazines				
No	185 (51.7%)	65 (56.5%)	120 (49.4%)	0.207
Yes	173 (48.3%)	50 (43.5%)	123 (50.6%)	
TV				
No	108 (30.2%)	36 (31.3%)	72 (29.6%)	0.747
Yes	250 (69.8%)	79 (68.7%)	171 (70.4%)	
Radio				
No	271 (75.7%)	89 (77.4%)	182 (74.9%)	0.607
Yes	87 (24.3%)	26 (22.6%)	61 (25.1%)	
Internet				
No	105 (29.3%)	39 (33.9%)	66 (27.2%)	0.190
Yes	253 (70.7%)	76 (66.10%)	177 (72.8%)	
Brochures, posters and other printed materials				
No	272 (76.0%)	92 (80.0%)	180 (74.1%)	0.220
Yes	86 (24.0%)	23 (20.0%)	63 (25.9%)	
Healthcare providers				
No	230 (64.2%)	86 (74.8%)	144 (59.3%)	0.004
Yes	128 (35.8%)	29 (25.2%)	99 (40.7%)	
Family members				
No	261 (72.9%)	82 (71.3%)	179 (73.7%)	0.639
Yes	97 (27.1%)	33 (28.7%)	64 (26.3%)	
Friends, neighbours, and colleagues				
No	231 (64.5%)	71 (61.7%)	160 (65.8%)	0.448
Yes	127 (35.5%)	44 (38.3%)	83 (34.2%)	
Reported sources of knowledge about COVID-19 vaccines*				
Newspapers and magazines				
No	219 (61.2%)	73 (63.5%)	146 (60.1%)	0.538
Yes	139 (38.8%)	42 (36.5%)	97 (39.9%)	
TV				
No	133 (37.2%)	38 (33.0%)	95 (39.1%)	0.269
Yes	225 (62.8%)	77 (67.0%)	148 (60.9%)	
Radio				
No	275 (76.8%)	89 (77.4%)	186 (76.5%)	0.859
Yes	83 (23.2%)	26 (22.6%)	57 (23.5%)	
Internet				
No	108 (30.2%)	39 (33.9%)	69 (28.4%)	0.288
Yes	250 (69.8%)	76 (66.1%)	174 (71.6%)	
Brochures, posters and other printed materials				
No	250 (69.8%)	90 (78.3%)	160 (65.8%)	0.017
Yes	108 (30.2%)	25 (21.7%)	83 (34.2%)	
Healthcare providers				
No	247 (69.0%)	91 (79.1%)	156 (64.2%)	0.004
Yes	111 (31.0%)	24 (20.9%)	87 (35.8%)	

Family members				
No	279 (77.9%)	88 (76.5%)	191 (78.6%)	0.658
Yes	79 (22.1%)	27 (23.5%)	52 (21.4%)	
Friends, neighbours, and colleagues				
No	232 (64.8%)	70 (60.9%)	162 (66.7%)	0.284
Yes	126 (35.2%)	45 (39.1%)	81 (33.3%)	

Data are presented as frequency (%).
#All the p values were computed based on Pearson chi-square test.
* multiple responses possible

Risk perception and self-efficacy

Majority of the participants agreed that COVID-19 was a serious disease (73.8%); their health would be severely affected if they got infected with COVID-19 (65.7%); and they were fearful that they would become infected (58.4%), or be quarantined (58.4%). However, only few (7.5%) perceived that they or their family members were at risk of COVID-19 infection. More than half of them were confident that they could protect themselves against COVID-19 (64.8%), and that the infection could finally be controlled in Hong Kong (55.7%) (See Table 4).

Table 4. Risk perception and self-efficacy.

Item	All (N=332)	Vaccinated against COVID-19		p-value#
		No (n=103)	Yes (n=229)	
Perceived risk of COVID-19				
1. I think COVID-19 is a serious disease.				
Strongly disagree/disagree/uncertain	87 (26.2%)	34 (33.0%)	53 (23.1%)	0.059
Agree/strongly agree	245 (73.8%)	69 (67.0%)	176 (76.9%)	
2. I think I will get infected with COVID-19.				
Strongly disagree/disagree/uncertain	307 (92.5%)	99 (96.1%)	208 (91.8%)	0.091
Agree/strongly agree	25 (7.5%)	4 (3.9%)	21 (9.2%)	
3. I think my family will get infected with COVID-19.				
Strongly disagree/disagree/uncertain	307 (92.5%)	100 (97.1%)	207 (91.4%)	0.032
Agree/strongly agree	25 (7.5%)	3 (2.9%)	22 (9.6%)	
4. I am fear of getting infected with COVID-19.				
Strongly disagree/disagree/uncertain	138 (41.6%)	42 (40.8%)	96 (41.9%)	0.845
Agree/strongly agree	194 (58.4%)	61 (59.2%)	133 (58.1%)	
5. I am fear of getting quarantined if get infected.				
Strongly disagree/disagree/uncertain	138 (41.6%)	43 (41.7%)	95 (41.5%)	0.964
Agree/strongly agree	194 (58.4%)	60 (58.3%)	134 (58.5%)	
6. My health will be severely affected if I get infected with COVID-19.				
Strongly disagree/disagree/uncertain	114 (34.3%)	39 (37.9%0	75 (32.8%)	0.364
Agree/strongly agree	218 (65.7%)	64 (62.1%)	154 (67.2%)	
7. I will not go to hospital even if I get sick because of risk of getting infected with COVID-19.				

Strongly disagree/disagree/uncertain	290 (87.3%)	88 (85.4%)	202 (88.2%)	0.482
Agree/strongly agree	42 (12.7%)	15 (14.6%)	27 (11.8%)	
Perceived self-efficacy in controlling COVID-19				
1. I believe I can protect myself against COVID-19.				
Strongly disagree/disagree/uncertain	117 (35.2%)	45 (43.7%)	72 (31.4%)	0.031
Agree/strongly agree	215 (64.8%)	58 (56.3%)	157 (68.6%)	
2. I believe COVID-19 can finally be successfully controlled.				
Strongly disagree/disagree/uncertain	147 (44.3%)	51 (49.5%)	96 (41.9%)	0.198
Agree/strongly agree	185 (55.7%)	52 (50.5%)	133 (58.1%)	
3. I have confidence that Hong Kong can win the battle against COVID-19.				
Strongly disagree/disagree/uncertain	142 (42.8%)	43 (41.7%)	99 (43.2%)	0.800
Agree/strongly agree	190 (57.2%)	60 (58.3%)	130 (56.8%)	

Data are presented as frequency (%).
[#]All the p values were computed based on Pearson chi-square test.

Factors associated with uptake of COVID-19 vaccination

From the bivariate analyses (Tables 1, 3 & 4), the uptake of COVID-19 vaccination was associated with current employment condition (p<0.001), perceived health status (p<0.001), perceived mental health status (p<0.001), contact with known suspected case(s) of COVID-19 (p<0.017), perceived exposure to COVID-19 (p=0.003), perceived knowledge of COVID-19 (p<0.001), perceived knowledge of COVID-19 vaccines (p<0.001), healthcare providers as a source of knowledge about COVID-19 (p=0.004), healthcare providers (p=0.017), and brochures, posters, and other printed materials (p=0.004) as sources of knowledge about COVID-19 vaccines, perception about family members being at risk of COVID-19 infection (p=0.032), and confidence in protecting themselves against COVID-19 (p=0.031).

The results from backward multivariable logistic regression analysis (see Table 5) revealed that the participants whose jobs were affected by COVID-19 (OR=4.83, 95% CI:1.18-19.76), had an income source (OR=2.10, 95% CI:1.18–3.72), perceived good/excellent physical health status (OR=5.09, 95% CI:1.17–22.08), perceived exposure to COVID-19 (OR=2.69, 95% CI:1.28–5.65), perceived to have good/ excellent knowledge of COVID-19 (OR=2.65, 95% CI:1.43–4.93), reported learning about COVID-19 vaccines from brochures, posters and other printed materials (OR=1.95, 95% CI:1.05-3.63), and perceived their family were at risk of

COVID-19 infection (OR=4.02, 95% CI:1.08-14.87) were positively associated with vaccination uptake. Alternatively, those reported learning about COVID-19 from the Internet were less likely to receive a COVID-19 vaccine (OR=0.50, 95% CI:0.26-0.98).

Table 5. Factors associated with the uptake of COVID-19 vaccination.

Factors retained in backward logistic regression analysis †	Odds ratio (95% CI)	p-value
Socio-demographic characteristics		
Current employment condition		
Unemployed/home maker (no source of income) (ref)	1	
Jobs affected by COVID-19	4.83 (1.18 – 19.76)	0.029
Have an income source	2.10 (1.18– 3.72)	0.011
Health conditions and lifestyle characteristics		
Perceived physical health status		
Poor/ fair (ref)	1	
Average	3.17 (0.80 – 12.63)	0.101
Good / excellent	5.09 (1.17 – 22.08)	0.030
Perceived mental health status		
Poor/ fair (ref)	1	
Average	1.47 (0.49 – 4.38)	0.490
Good / excellent	3.23 (0.99 – 10.53)	0.052
Experience or perceptions related to COVID-19		
Perceived exposure to COVID-19		
No (ref)	1	
Yes	2.69 (1.28 – 5.65)	0.009
Perceived knowledge on COVID-19		
Poor/ fair	1.12 (0.28 – 4.53)	0.875
Average (ref)	1	
Good / excellent	2.65 (1.43– 4.93)	0.002
Sources of knowledge		
Reported Internet as a source of knowledge about COVID-19		
No	1	
Yes	0.50 (0.26 – 0.98)	0.045
Reported brochures, posters and other printed materials as sources of knowledge about COVID-19 vaccines		
No	1	
Yes	1.95 (1.05 – 3.63)	0.035
Perceived risk of COVID-19		
I think my family will get infected with COVID-19.		
Strongly disagree/disagree/uncertain	1	
Agree/strongly agree	4.02 (1.08 – 14.87)	0.037

† Significant factors retained from backward multivariable logistic regression analysis using the variables as listed in Tables 1, 3&4 with p-value <0.25 in univariate analysis as candidate independent variables
CI: confidence interval; ref: reference category of categorical independent variable

DISCUSSION

To our knowledge, this study is one of the few studies that explored the factors influencing actual vaccination uptake during the COVID-19 pandemic among community members in

Hong Kong and worldwide. In our study, approximately 70% of the sample received at least one dose of the vaccine, which is higher than the officially announced vaccination uptake rate (~50%)[10] and that reported in two local cross-sectional studies during the same study period[21,22]. Despite the high vaccination uptake, half of the unvaccinated respondents indicated that the willingness to be vaccinated in the next 15 days was low, revealing a considerable level of vaccine hesitancy in our sample. This finding echoed with other local public health studies[21,22] in which the main concerns reported by unvaccinated people were the side effects and safety of available vaccines. This was also a well-recognised or commonly cited reason for vaccine hesitancy reported consistently in different countries[13-15,21,22,24,25]. This implies that further efforts in public education should focus on conveying scientific evidence and knowledge about the efficacy and safety of various available vaccines to enhance their evidence-based decision-making on vaccination.

Among various socio-demographic factors, employment condition was found to be an independent determinant of vaccination uptake. Specifically, those who were unemployed or homemaker were less likely to be vaccinated than those who were working or who had their employment affected by the COVID-19 pandemic. As increasing number of employers adopted vaccination instead of regular testing approaches proposed by the (local) government, unvaccinated employees would require to undergo self-financed COVID-19 testing every two weeks[26]. Such testing requirements may encourage more employees or job seekers to get vaccinated. Similarly, a recent international study found that people who were unemployed but not seeking a job reported a lower intention to be vaccinated[13]. This suggests that vaccination campaigns highlighting the financial or economic benefits of vaccination to the working population (such as resuming normal business conditions and more job opportunities) may be effective. Nevertheless, efforts should also be made to promote the various benefits of

vaccination to non-working population, such as a gradual return to normal life after achieving herd community.

This study identified several knowledge-related factors influencing vaccination uptake. In the bivariate analysis, both perceived knowledge of COVID-19 and its vaccines were associated with vaccination uptake, but only perceived knowledge of COVID-19 was remained a significant factor in the multivariable model. Likewise, a recent British population-based survey showed that the perception of sufficient information/knowledge about COVID-19 and the vaccine was positively correlated with the intention to vaccinate[15]. Regarding information sources, our study found that those who learned about the COVID-19 vaccines through brochures, posters, and other printed materials were more likely to receive the vaccine. Interestingly, those who reported that they learned from the Internet were less likely to be vaccinated. One possible explanation for these findings is that printed materials are more likely to be produced by authoritative bodies (e.g., Department of Health[27]) based on the latest scientific evidence, while the Internet is often fueled by the spread of inaccurate information (i.e., an infodemic in which health information was mixed with fear, speculation and rumor, amplified swiftly worldwide by technologies such as internet)[28]; whereas, higher news consumption through social media was associated with lower levels of knowledge and more fake news beliefs[29]. In this regard, a recent randomised controlled trial in the United Kingdom and United States suggested that exposure to online misinformation can reduce the public's intention to vaccinate[18].

In line with the finding that protecting friends and family being the major reason for vaccination, we found that individual who perceived their family members were at risk of contracting COVID-19 were more likely to be vaccinated than those who have not reported this perception. Similarly, there are several reports that consideration of others, particularly family members, with respect to the threat of COVID-19 affects vaccination intention[13,15,18].

Taken together, these results suggest that vaccination promotion messages should emphasise on the altruistic benefits of vaccination to significant others and society at large, for example, the effectiveness of vaccination in reducing the infection risk at individual and collective levels[30].

In this study, people's perceived COVID-19 exposure independently predicted their vaccination uptake. To our knowledge, this factor has not been reported as a predictor of vaccination intention or acceptance in previous studies. It can be speculated that those who perceive that they have not been exposed to the COVID-19 may not feel the urgency of vaccination, leading to vaccine hesitancy.

Of note, perceived to have good/excellent physical health status was the strongest factor for vaccination uptake (OR=5.09) in the final regression model. Likewise, this factor has been found to predict the intention of vaccination against COVID-19 among the general population in China[25] and actual vaccination uptake in a sample of elderly population in Germany[17]. It could be possible that people who perceive they were in poor health might be more worried about the side effects of the vaccine, which would become a major obstacle to vaccination.

Limitations

This study has several limitations. First, this study adopted a cross-sectional design so that the causality between vaccination uptake and other variables could not be determined. Second, a non- random sample was used; and this might lead selection bias and limit the generalizability of the findings. Third, the sample was found to be over-represented by female, highly educated and younger adults, so caution is needed to be taken when generalising the findings to the general population in Hong Kong. Finally, the use of self-report questionnaires might also be subject to social desirability bias and inaccurate understanding and responses to the questionnaire, thereby reducing the reliability and validity of the findings.

CONCLUSION

This study is one of the few survey studies aimed at exploring the reasons and factors associated with the 'actual' vaccination uptake among general population during the COVID-19. The results provide evidence and insights for formulating effective strategies to promote COVID-19 vaccination in Hong Kong and other developed countries.

Acknowledgements

The authors would like to thank all the participants in the study.

Contributors

CLW and WTC contributed to study conception and design. CLW was involved in gaining ethical approval. CLW involved in data collection. CLW, AWYL and OMHC analysed the data and wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Funding

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

Competing interests

The authors declare that there is no conflict of interest.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication

Not required

Provenance and peer review

Not commissioned; externally peer reviewed.

Data availability statement

The anonymous data which form the basis for this study are available from the authors on reasonable request.

REFERENCES

1. Coronavirus Resource Center. COVID-19 Dashboard, https://coronavirus.jhu.edu/map.html (2021, accessed 31 August 2021).
2. The Government of Hong Kong Special Administrative Region. Together,We Fight the Virus! https://www.coronavirus.gov.hk/eng/index.html (2021, accessed 31 August 2021).
3. Altig D, Baker S, Barrero JM, et al. Economic uncertainty before and during the COVID-19 pandemic. *J Public Econ* 2020;191:104274. https://doi.org/10.1016/j.jpubeco.2020.104274.
4. Wu T, Jia X, Shi H, et al. Prevalence of mental health problems during the COVID-19 pandemic: a systematic review and meta-analysis. *J Affect Disord* 2021;281:91-8. https://doi.org/10.1016/j.jad.2020.11.117.
5. World Health Organization. COVID-19 advice for the public: getting vaccinated, https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines/advice (2021, accessed 31 August 2021).
6. Kwok KO, McNeil EB, Tsoi MTF, et al. Will achieving herd immunity be a road to success to end the COVID-19 pandemic? *J Infect* 2021; 83:381-412. https://doi.org/10.1016/j.jinf.2021.06.007.
7. Kwok KO, Lai F, Wei WI, et al. Herd immunity-estimating the level required to halt the COVID-19 epidemics in affected countries. *J Infect* 2020;80(6):e32-e3. https://doi.org/10.1016/j.jinf.2020.03.027.
8. World Health Organization. Report of the SAGE Working Group on Vaccine Hesitancy, http://www.who.int/immunization/sage/meetings/2014/october/SAGE_working_group_revised_report_vaccine_hesitancy.pdf (2015, accessed 19 August 2021).

9. World Health Organization. Ten threats to global health in 2019, https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019 (2021, accessed 19 August 2021).

10. The Government of Hong Kong Special Administrative Region. COVID-19 vaccination programme, https://www.covidvaccine.gov.hk/en/ (2021 accessed 19 August 2021).

11. The Government of Hong Kong Special Administrative Region. Early Vaccination for All" campaign launched, https://www.info.gov.hk/gia/general/202105/31/P2021053100749.htm (2021 May 31, accessed 19 August 2021).

12. news.gov.hk. Early vaccination urged, https://www.news.gov.hk/eng/2021/07/20210718/20210718_131218_995.html (2021 July 18, accessed 19 August 2021).

13. Burke PF, Masters D, Massey G. Enablers and barriers to COVID-19 vaccine uptake: an international study of perceptions and intentions. *Vaccine* 2021;39(36):5116-28. https://doi.org/10.1016/j.vaccine.2021.07.056.

14. Soares P, Rocha JV, Moniz M, et al. Factors associated with COVID-19 vaccine hesitancy. *Vaccines* 2021;9(3):300. https://doi.org/10.3390/vaccines9030300.

15. Sherman SM, Smith LE, Sim J, et al. COVID-19 vaccination intention in the UK: results from the COVID-19 vaccination acceptability study (CoVAccS), a nationally representative cross-sectional survey. *Hum Vaccin Immunother* 2021;17(6):1612-21. https://doi.org/1080/21645515.2020.1846397.

16. Viswanath K, Bekalu M, Dhawan D, et al. Individual and social determinants of COVID-19 vaccine uptake. *BMC Public Health*. 2021;21(1):818. https://doi.org/10.1186/s12889-021-10862-1.

17. Malesza M, Wittmann E. Acceptance and intake of COVID-19 vaccines among older Germans. *J Clin Med* 2021;10(7). https://doi.org/10.3390/jcm10071388.

18. Loomba S, de Figueiredo A, Piatek SJ, et al. Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. *Nat Hu Behav* 2021;5(3):337-48. https://doi.org/10.1038/s41562-021-01056-1.

19. Wong MCS, Wong ELY, Huang J, et al. Acceptance of the COVID-19 vaccine based on the health belief model: a population-based survey in Hong Kong. *Vaccine* 2021;39(7):1148-56. https://doi.org/10.1016/j.vaccine.2020.12.083.

20. Kwok KO, Li KK, Tang A, et al. Psychobehavioral responses and likelihood of receiving COVID-19 vaccines during the pandemic, Hong Kong. *Emerg Infect Dis* 2021;27(7):1802-10. https://doi.org/10.3201/eid2707.210054.

21. The Chinese University of Hong Kong. Survey findings on views about COVID-19 released by Hong Kong Institute of Asia-Pacific Studies at CUHK, https://www.cpr.cuhk.edu.hk/en/press/survey-findings-on-views-about-covid-19-released-by-hong-kong-institute-of-asia-pacific-studies-at-cuhk-6/ (2021 August 4, accessed 10 August 2021).

22. The Baptist University of Hong Kong. Vaccine Hesitancy Study Reports, https://research.hkbu.edu.hk/highlighted-projects/overcoming-vaccine-hesitancy-in-hong-kong#Reports (2021, accessed 20 August 2021).

23. Wong CL, Chen J, Chow KM, et al. Knowledge, attitudes and practices towards COVID-19 amongst ethnic minorities in Hong Kong. *Int J Environ Res Public Health* 2020;17(21): 7878. https://doi.org/10.3390/ijerph17217878.

24. Wang K, Wong EL, Ho K-F, et al. Change of willingness to accept covid-19 vaccine and reasons of vaccine hesitancy of working people at different waves of local epidemic

in Hong Kong, China: repeated cross-sectional surveys. *Vaccines* 2021;9(1). https://doi.org/10.3390/vaccines9010062.

25. Wang J, Zhang Y, Long S, et al. Non-EPI vaccine hesitancy among Chinese adults: a cross-sectional study. *Vaccines* 2021;9(7). https://doi.org/10.3390/vaccines9070772.
26. The Government of Hong Kong Special Administrative Region. Government tightens eligibility criteria for free COVID-19 testing for targeted groups at community testing centres, https://www.info.gov.hk/gia/general/202108/04/P2021080401030.htm (2021 August 4, accessed 20 August 2021).
27. Hong Kong Department of Health. Health Education Materials, https://www.chp.gov.hk/en/features/102745.html (2021, accessed 31 August 2021).
28. Eysenbach G. Infodemiology: the epidemiology of (mis)information. *Am J Med* 2002;113(9):763-5. https://doi.org/10.1016/S0002-9343(02)01473-0
29. Gerosa T, Gui M, Hargittai E, et al. (Mis)informed during COVID-19: how education level and information sources contribute to knowledge gaps. *Int J Commun* 2021;15:2196-217.
30. Barello S, Palamenghi L, Graffigna G. Looking inside the 'black box' of vaccine hesitancy: unlocking the effect of psychological attitudes and beliefs on COVID-19 vaccine acceptance and implications for public health communication. *Psychol Med* 2021; Epub 2021/03/08. https://doi.org/10.1017/S003329172100101X

Factors influencing COVID-19 vaccination uptake: a cross-sectional online survey

Background: The continued spread COVID-19 in Hong Kong poses a significant impact on community members. Vaccination is recognised to be the most effective approach to contain the spread of the COVID-19 pandemic in a long run. However, the vaccination uptake in Hong Kong is still suboptimal. Little is known about the factors that influence COVID-19 vaccination uptake among the general public in Hong Kong.

Purpose: To examine factors that affect actual COVID-19 vaccination uptake among community members in Hong Kong.

Design: A cross-sectional design.

Methods: A total of 340 community members will be recruited online. A set of self-developed questionnaire will be used to assess sociodemographic characteristics, vaccination status, perceived impact of COVID-19, and their attitudes towards COVID-19.

Data analysis: Quantitative data analysis will be conducted.

Potential significance: The findings are imperative to inform strategies to increase COVID-19 vaccination rates in Hong Kong.

Introduction

Coronavirus disease 2019 (COVID-19) is an emerging respiratory disease caused by a novel coronavirus (Wang et al., 2020). The disease was first discovered in Wuhan, Hubei Province in December 2019 (Bai et al., 2020). The ongoing COVID-19 pandemic has spread quickly, with confirmed cases having been reported in the majority of countries worldwide. The World Health Organisation (WHO) declared the disease a public health emergency of international concern on January 30 and called on all countries to work together to prevent the worsening of the pandemic (WHO, 2020). Some unprecedented restrictive measures have been implemented in several countries to contain its spread, including strict "lock down" regulations, closing of premises and public places, compulsory quarantine measures, and isolation care for infected persons and suspected cases. As of April 6, 2021, statistics on the WHO Coronavirus Disease (COVID-19) Dashboard show that the virus has spread to 221 countries, with approximately 131.02 million confirmed cases and over 2.85 million deaths (WHO, 2021a). Compared with other countries in the world, Hong Kong is moderately affected by the COVID-19 pandemic, but is being struck with the fourth wave of COVID-19 in recent days. Since the outbreak, a total of 11,532 COVID-19 cases have been recorded, of which 205 people have died of this disease (Centre for Health Protection, 2021).

Vaccination is one of the most effective ways to prevent further morbidity and mortality and to promote herd immunity. As of February 18, 2021, at least seven different COVID-19 vaccines have been launched on three platforms in different countries, including inactivated or weakened virus vaccines, protein-based vaccines, viral vector vaccines, and RNA and DNA vaccines (WHO, 2021b). In Hong Kong, a territory-wide COVID-19 Vaccination Programme free of charge and on a voluntary basis for all eligible residents has been implemented by the Hong Kong government to protect members of public against COVID-19. Two intramuscular administered COVID-19 vaccines have been authorized for use: Inactivated (CoronaVac) and COMIRNATYTM COVID-19 mRNA Vaccine (BNT162b2) (COMIRNATY). Individuals are required to receive two doses of the same vaccine to build up adequate protection. As of 5 April 2021, about 487,000 Hong Kong people have been vaccinated for 1st dose, and 90,200 have fully vaccinated (The Government of Hong Kong Special Administrative Region, 2021). Nevertheless, herd immunity against COVID-19 requires at least 70% of population to be vaccinated. The slow vaccination progress calls for more effective strategies to overcome barriers.

Emerging epidemiological evidence suggests a broad array of factors that may affect vaccination intention among the general public, including sociodemographic factors such as

age (Sherman et al., 2021; Soares et al., 2021) and employment status (Soares et al., 2021); disease-specific factors such as risk perception (Malesza & Wittmann, 2021; Sherman et al., 2021;) and COVID-19 information exposure (Loomba, de Figueiredo, Piatek, de Graaf, & Larson, 2021; Malesza & Wittmann, 2021; Sherman et al., 2021; Soares et al., 2021;) and vaccine-specific factors such as confidence in efficacy and safety (Malesza & Wittmann, 2021; Sherman et al., 2021; Soares et al., 2021; Wong et al., 2021) and vaccination attitudes (Sherman et al., 2021). However, the major factors influencing actual vaccine uptake have seldom been explored. A recent cross-sectional study on 1,037 older Germans suggested that general health condition, the presence of chronic conditions, perceptions of infection, the severity of potential long-term effects, the efficacy of vaccines, the benefits of vaccination, the negative side-effects of vaccines and the general impediments to vaccination were the factors influencing actual vaccination (Malesza & Wittmann, 2021).

Existing studies on vaccination intentions are largely conducted prior to the commencement of the worldwide mass vaccination programmes. As far as we know, there is no known information about the factors influencing actual vaccination uptake. Therefore, the novelty of this study is to examine the factors that affect actual vaccination uptake among community members of Hong Kong.

Methods

Study design

This study uses a cross-sectional design.

Setting and sample

Participants will be recruited online. To be eligible to participate in this study, potential community members are (1) 18 years of age or older; (2) able to communicate in Chinese or English. Participants who suffer from cognitive impairment or self-disclose of having major depressive disorder will be excluded. The sample size is determined to allow adequate precision to estimate the COVID-19 vaccination rate. By using the power analysis software, PASS 16.0 (NCSS, Kaysville, US), it is estimated that a sample size of n=340 participants would allow the study to estimate the uptake rate with a margin of error of at most ±5% at a level of significance of 0.05 on the basis of an anticipated uptake rate of around one-third.

For the online survey, an online survey portal will be created using SurveyMonkey, a secure cloud-based online survey platform. The brief study description, consent forms and questionnaires will be included in the online survey portal. Participants will be invited to

participate the study via convenience and snowball sampling methods. Participants will be responded to the invitation by clicking a link that direct them to the online survey portal. They will be asked to click the "yes" button to indicate their consent to the study and complete the socio-demographics and background information as well as a set of self-developed questionnaire online.

Survey Instrument

A set of questionnaires comprised of three sections is developed by the research team with references to previous studies of similar topics (Malesza & Wittmann, 2021; Soares et al., 2021;Wong et al., 2020). The questionnaire has been reviewed by a panel of experts and will be validated with 20 participants representing the target population before the main study for their understanding of the questionnaire content before the main study.

The questionnaire consists of three sections that aim to collect the following information from the participants:

1. Participants' socio-demographic characteristics, health conditions and lifestyle characteristics, including age, gender, place of birth, living status, marital status, highest educational qualification, current employment condition, co-morbidities, smoking and alcohol drinking status, perceived physical and mental health status.
2. Vaccination status and perceived impact of COVID-19: uptake of COVID-19 vaccination (yes/no), reasons for/against vaccination (an open-ended question), impact of COVID-19 on financial situation, contact with known/suspected cases of COVID-19, perceived COVID-19 exposure, perceived knowledge of COVID-19 and COVID-19 vaccines, sources of information about COVID-19 and COVID-19 vaccines, healthcare service used to overcome COVID-19 related stress in the past six months.
3. Attitudes towards COVID-19: a 10-item questionnaire developed by the research team (Wong et al., 2020). The questionnaire comprises two subscales: perceived risk of COVID-19 (7 items) and perceived self-efficacy in controlling COVID-19 (3 items). Each item is rated on a 5-point Likert scale (from 1='strongly disagree' to 5='strongly agree'.

Statistical analysis

IBM SPSS Statistics for Windows version 25.0 (IBM Corp., Armonk, NY, USA) will be used for statistical analysis. For the online questionnaire responses, they will be downloaded, coded and input into the SPSS. Descriptive statistics, such as mean and standard deviations

(SD) for continuous variables and proportions for categorical variables, will be used to summarize outcome variables as well as participants' demographics characteristics. These characteristics will be compared between the participants who had vaccinated (at least one dose) and those who had not, using Pearson's chi-square test. Those factors showing significance ($p < 0.25$) in bivariate analyses will be selected as candidate variables for backward multivariable logistic regression analysis to delineate factors significantly associated with their vaccination status. The statistical significance level is set at $p < 0.05$ (two-sided).

Ethical consideration

Ethical approval will be obtained from the Chinese University of Hong Kong's Survey and Behavioural Research Committee. All study procedures involving human participants will be handled in accordance with the Helsinki Declaration. The participants will be assured that their participation is voluntary, their rights to withdraw at any time will be upheld and their information will be confidential. All information will be kept safely in a locked file that could only be accessed by the researcher. All data will be destroyed six months after the project has completed.

Significance of the study

This study is one of the few survey studies aims at exploring the reasons and factors associated with the 'actual' vaccination uptake among general population during the COVID-19. The results will provide evidence and insights for formulating effective strategies to promote COVID-19 vaccination in Hong Kong and other developed countries.

References

Bai, Y., Yao, L., Wei, T., Tian, F., Jin, D. Y., Chen, L., Wang, M. (2020). Presumed asymptomatic carrier transmission of COVID-19. *JAMA, 323*(14), 1406-1407.

Centre for Health Protection, Hong Kong. (2021, April 6). *Latest Situation of Novel Coronavirus infection in Hong Kong.* https://www.coronavirus.gov.hk/eng/index.html

Loomba, S., de Figueiredo, A., Piatek, S. J., de Graaf, K., & Larson, H. J. (2021). Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. *Nature Human Behaviour, 5*(3), 337-348.

Malesza, M., & Wittmann, E. (2021). Acceptance and intake of COVID-19 vaccines among older Germans. *Journal of Clinical Medicine, 10*(7).

Sherman, S. M., Smith, L. E., Sim, J., Amlôt, R., Cutts, M., Dasch, H., . . . Sevdalis, N. (2021). COVID-19 vaccination intention in the UK: results from the COVID-19 vaccination acceptability study (CoVAccS), a nationally representative cross-sectional survey. *Human Vaccines & Immunotherapeutics, 17*(6), 1612-1621.

Soares, P., Rocha, J. V., Moniz, M., Gama, A., Laires, P. A., Pedro, A. R., . . . Nunes, C. (2021). Factors associated with COVID-19 vaccine hesitancy. *Vaccines, 9*(3), 300. doi:10.3390/vaccines9030300

The Government of the Hong Kong Special Administrative Region. (2021, 6 April). Vaccination Dashboard. https://www.covidvaccine.gov.hk/en/dashboard

Wang, C., Horby, P. W., Hayden, F. G., & Gao, G. F. (2020). A novel coronavirus outbreak of global health concern. *Lancet, 395*(10223), 470-473.

Wong, C. L., Chen, J., Chow, K. M., Law, B. M. H., Chan, D. N. S., So, W. K. W., Leung, a W. Y., & Chan, C. W. H. (2020). Knowledge, attitudes and practices towards COVID-19 amongst ethnic minorities in Hong Kong. International Journal of Environmental Research and Public Health, 17(21), 7878.

Wong, M. C. S., Wong, E. L. Y., Huang, J., Cheung, A. W. L., Law, K., Chong, M. K. C., . . . Chan, P. K. S. (2021). Acceptance of the COVID-19 vaccine based on the health belief model: A population-based survey in Hong Kong. Vaccine, 39(7), 1148-1156.

World Health Organizatio (2020, January 31). *2019-nCoV outbreak is an emergency of international concern.* https://www.euro.who.int/en/health-topics/health-emergencies/pages/news/news/2020/01/2019-ncov-outbreak-is-an-emergency-of-international-concern

World Health Organization (2021a, April 6). *WHO Coronavirus Disease (COVID-19) Dashboard.* https://covid19.who.int

World Health Organization (2021b, March 19). *COVID-19 vaccines* https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7-8*
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	10-14

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	14-15
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Factors influencing COVID-19 vaccination uptake among community members in Hong Kong: a cross-sectional online survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-058416.R1
Article Type:	Original research
Date Submitted by the Author:	30-Dec-2021
Complete List of Authors:	Wong, Cho Lee; The Chinese University of Hong Kong The Nethersole School of Nursing Leung, Alice; The Chinese University of Hong Kong The Nethersole School of Nursing Chung, Oscar ; The Chinese University of Hong Kong The Nethersole School of Nursing Chien, Wai-Tong; The Chinese University of Hong Kong The Nethersole School of Nursing
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology
Keywords:	COVID-19, Epidemiology < TROPICAL MEDICINE, INFECTIOUS DISEASES

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Factors influencing COVID-19 vaccination uptake among community members in Hong Kong: a cross-sectional online survey

Cho Lee Wong, Alice Wai Yi Leung, Oscar Man Hon Chung, Wai Tong Chien*

The Nethersole School of Nursing, Faculty of Medicine, The Chinese University of Hong, Hong Kong

***Corresponding author:**
Wai Tong Chien
Director and Professor
The Nethersole School of Nursing, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong
Tel: (852) 3943 8172;
E-mail: wtchien@cuhk.edu.hk

Contact information of first author
Cho Lee Wong
Assistant Professor
The Nethersole School of Nursing, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong
Tel: (852) 3943 8166;
E-mail: jojowong@cuhk.edu.hk

Word Count: 3467

ABSTRACT

Objective: Vaccination is recognized as the most effective approach to contain the spread of the COVID-19 pandemic in the long run. However, the global vaccination uptake is still suboptimal. Although a considerable number of studies have focused on factors influencing intention or acceptance of COVID-19 vaccination, few explore the factors that affect actual vaccination uptake. This study aimed to explore the factors influencing COVID-19 vaccination uptake among the general public in a developed country.

Design: A cross-sectional online survey was conducted between June and August 2021.

Setting and participants: Community members in Hong Kong were recruited through convenient and snowball sampling to complete an anonymous online survey.

Outcome measures: The outcomes of this study included participants' sociodemographic characteristics, vaccination status and perceived impact of COVID-19, and their attitudes towards COVID-19.

Results: A total of 358 valid questionnaires were received. The results showed that 50.8% of the participants received two doses of the vaccine. Multivariable logistic regression analysis suggested that the participants' vaccination uptake was associated with their jobs affected by COVID-19, had an income source, perceived good/excellent physical health status, perceived COVID-19 exposure, perceived good/excellent knowledge of COVID-19, learned about the vaccine from printed materials and perceived that their family members were at risk of contracting COVID-19.

Conclusions: This is one of the first few cross-sectional studies that explored factors associated with the actual vaccination uptake of the general public during the COVID-19 pandemic. The results can provide insights for formulating strategies to increase COVID-19 vaccination rates in developed countries.

Keywords: vaccination uptake, factors, COVID-19

Strengths and limitations of this study

- This study explored factors associated with the actual vaccination uptake among Hong Kong community members during the COVID-19 pandemic, including socio-demographics, perceived impact of COVID-19, and attitudes towards COVID-19.
- This study adopted a cross-sectional design so that the causality cannot be ascertained.
- This non-random sample was over-represented by female, highly educated and younger adults.
- The use of self-report questionnaires might also be subject to social desirability bias and inaccurate understanding and responses to the questionnaire.

INTRODUCTION

Shortly after the Coronavirus disease 2019 (COVID-19) outbreak in China around December 2019, the infection quickly spread across the globe and caused disturbances in many aspects of life. As of August 31, 2021, more than 217 million infected cases and more than 4.5 million deaths have been recorded worldwide[1]. At the same time, Hong Kong has experienced four waves of COVID-19 infection, with confirmed cases and deaths stagnating at around 12,000 and 200, respectively[2].

To contain the spread of the pandemic, governments around the world have adopted measures such as social distancing and border control. These measures imposed many restrictions on individuals and caused heavy health and economic losses[3,4]. Alternatively, achieving herd immunity against COVID-19 through vaccinations is considered the most effective means to contain the spread of the pandemic in the long run[5,6].

As of August 31, 2021, only 27.1% of the global population has been fully vaccinated [1]. The current vaccination rate in most countries is far below the target group herd immunity thresholds (15.3%-77.1%)[7]. Due to the ample supply of vaccines in high- and upper middle-income countries, the suboptimal COVID-19 vaccination rate in most countries indicate that vaccine hesitancy is prevalent. The World Health Organization defines vaccine hesitancy as "the delay in acceptance or refusal of vaccination despite the availability of vaccination services"[8], and listed it as one of the 10 top/major threats to global health in 2019[9].

In Hong Kong, the government has launched a territory-wide vaccination program on February 26, 2021, providing all Hong Kong residents with free CoronaVac (Sinovac) inactivated vaccine and the Comirnaty (BioNTech) mRNA vaccine[10]. The vaccination progress had been slow until a sudden surge was observed in mid-June (7-day moving average of total doses administered >40,000[10]), which might be attributable to the government's "Early Vaccination for All" campaign, which features the facilitation and reward strategies for

vaccinated people (for example, vaccination leave and relaxation of social distancing)[11]. In addition, the business sector also held some lucky draws (for example, the first prize of a HK$ 7 million flat, HK$ 1 million) to boost the COVID-19 vaccination rate. However, the current vaccination rate in Hong Kong (around 50% at the end of August) is still far from reaching the target of at least 70% of the eligible population[12]. The suboptimal vaccination rates call for more effective strategies to overcome barriers, not just merely provide incentives.

Emerging epidemiological evidence suggests a broad array of factors that affect the intention to vaccinate against COVID-19 among the general public, including sociodemographic factors such as age[13-15] and employment status[13,14]; disease-specific factors such as risk perception[15-17] and COVID-19 information exposure[14-18]; and vaccine-specific factors such as confidence in efficacy and safety[13-15,17,19] and vaccination attitudes[15,20,21]. However, the major factors influencing actual vaccine uptake have seldom been explored. A recent cross-sectional study on 1,037 older Germans suggested that general health condition, the presence of chronic conditions, perceptions of infection, the severity of potential long-term effects, the efficacy of vaccines, the benefits of vaccination, the negative side-effects of vaccines and the general impediments to vaccination were the determinants of actual vaccination[17].

After the launch of the territory-wide vaccination program in Hong Kong, a few population-based surveys have explored the factors that influence vaccination uptake. These surveys reported a vaccine hesitancy rate of 27.6-44.6%[22,23].The major reasons for vaccine hesitancy included physically unfit for vaccination due to medical reasons [22] and worried about serious side effects of vaccines[22,23]. In a telephone survey on Hong Kong citizens' attitudes and opinions on vaccination, respondents who had received the vaccine had a significantly higher rating on the government's anti-epidemic efforts than those who had not been vaccinated [23].

Existing studies on vaccination intentions are largely conducted before the commencement

of the worldwide mass vaccination program. With the further advancement of vaccine technology and the rapid emergence of COVID-19 variants, the factors that predict the actual vaccine uptake have yet to be determined. In this context, there is an urgent need to conduct more studies to investigate the factors related to actual vaccination uptake to inform the current and future measures to promote vaccination uptake in Hong Kong and other developed countries. Therefore, this study aimed to explore the factors that affect COVID-19 vaccine uptake among general populations in Hong Kong.

METHODS

Study design

This study adopted a cross-sectional design using an online survey.

Setting and sample

Participants were recruited online from June to August 2021. Eligible participants were community members (1) aged 18 or above; (2) able to understand the instructions and items of the questionnaire in either Chinese or English; and (3) given written consent (by answering 'yes' on the first page of the survey). Participants who self-disclosed that they had major depressive disorder, cognitive impairment, or illiteracy were excluded.

The sample size was determined to allow adequate precision to estimate the COVID-19 vaccination rate. By using the power analysis software, PASS 16.0 (NCSS, Kaysville, US), it was estimated that a sample size of n=340 participants would allow the study to estimate the uptake rate with a margin of error of at most ±5% at a level of significance of 0.05 based on an anticipated uptake rate of around one-third.

For the online surveys, an online survey portal was created using SurveyMonkey, a secure cloud-based online survey platform. A brief study description, consent form, and

questionnaires were included in the online survey portal. Participants were invited to participate in the study through the social messaging mobile application WhatsApp. A link was rolled out through various WhatsApp groups from staff working in a local university. Participants were recruited through convenient and snowball sampling. All respondents were asked to forward the link to their family and friends. Potential participants responded to the invitation by clicking a link that directed them to the online survey portal. They were asked to click the "yes" button on the first page of study information and instructions to indicate their consent to participate. After consented, they would complete a set of self-developed questionnaire online, lasting about 8-10 minutes. The study protocol is shown in supplementary file 1.

Survey Instrument

The research team developed a set of questionnaires comprising three sections with references to previous studies of similar topics[14,16,24], and the current recommendations and guidelines from health authorities. The primary version was prepared in English and translated into Cantonese using standard translating procedures. The translated version was then reviewed by a panel of experts to ensure semantic and content equivalence. A convenience sample of 20 community members of different ages was then invited to comment on the clarity of the items and whether they had difficulty in answer the questions before actual use. All of them reported they had no difficulty in understanding the questions. The questionnaire (supplementary file 2) consisted of three sections:

1. Participants' socio-demographic characteristics, health conditions and lifestyle characteristics, including age, gender, place of birth, living status, marital status, highest educational qualification, current employment condition, co-morbidities, smoking and alcohol drinking status, perceived physical and mental health status.

2. Vaccination status and perceived impact of COVID-19: uptake of COVID-19 vaccination (yes/no), reasons for/against vaccination (an open-ended question), the impact of COVID-19 on the financial situation, contact with known/suspected cases of COVID-19, perceived COVID-19 exposure, perceived knowledge of COVID-19 and COVID-19 vaccines, sources of information about COVID-19 and COVID-19 vaccines, healthcare service used to overcome COVID-19 related stress in the past six months.

3. Attitudes towards COVID-19: a 10-item questionnaire developed by the research team[24]. The questionnaire comprises two subscales: perceived risk of COVID-19 (7 items) and perceived self-efficacy in controlling COVID-19 (3 items). Each item was rated on a 5-point Likert scale (from 1='strongly disagree' to 5='strongly agree'. The internal consistency of the scale in this study was satisfactory (Cronbach's alpha=0.71).

Statistical analysis

The participant's characteristics, including socio-demographics, health conditions and lifestyle characteristics, and experience or perceptions related to COVID-19, perceived risk of COVID-19 and perceived self-efficacy in controlling COVID-19 were categorized and presented using frequency and percentage. These characteristics were compared between the participants who had been vaccinated (at least one dose) and those who had not, using Pearson's chi-square test. Those characteristics with $p<0.25$ in univariate analyses were selected as candidate independent variables for a backward multivariable logistic regression analysis to delineate factors significantly and independently associated with their vaccination status. All statistical analyses were performed using IBM SPSS 25.0 (IBM Corp, Armonk, NY), and the level of significance was set at 0.05 (two-sided).

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Ethical considerations

Ethical approval was obtained from the Survey and Behavioural Research Committee of The Chinese University of Hong Kong (SBRE-20-784). The Helsinki Declaration handled all study procedures involving human subjects. The participants were assured that their participation was voluntary, their rights to withdraw at any time were upheld, and their information was confidential.

RESULTS

Sample characteristics

A total of 384 community members consented online and participated in the study. Twenty-six respondents were excluded from the analyses due to having missing data on more than 30% of the questionnaire items. The remaining participants completed all the items in the questionnaire. Hence, the final sample were 358 participants (i.e., completion rate=93.2%). The mean age of the participants was 38.27 (SD=14.79), and 69.0% were female. Table 1 shows a summary of the socio-demographic characteristics, health conditions and lifestyle characteristics of the participants.

Table 1. Characteristics of the study sample (N=358).

	All (N=358)	Vaccinated against COVID-19		p-value #
		No (n=115)	Yes (n=243)	
	n (%)	n (%)	n (%)	
Socio-demographic characteristics				
Age (years)				
18 – 29	127 (35.5)	42 (36.5)	85 (35.0)	0.254
30 – 59	202 (56.4)	60 (52.2)	142 (58.4)	
≥ 60	29 (8.1)	13 (11.3)	16 (6.6)	
Gender				
Female	247 (69.0)	85 (73.9)	162 (66.7)	0.166
Male	111 (31.0)	30 (26.1)	81 (33.3)	

Born in Hong Kong				
No	48 (13.4)	13 (11.3)	35 (14.4)	0.422
Yes	310 (86.6)	102 (88.7)	208 (85.6)	
Living status				
Live without family members	34 (9.5)	8 (7.0)	26 (10.7)	0.259
Live with family members	324 (90.5)	107 (93.0)	217 (89.3)	
Marital status				
Single/ divorced/ widowed	194 (54.2)	60 (52.2)	134 (55.1)	0.598
Cohabiting/ married	164 (45.8)	55 (47.8)	109 (44.9)	
Highest educational qualification				
Secondary/ higher secondary/ grade 7 to 12 or below	76 (21.2)	32 (27.8)	44 (18.1)	0.055
Certificate/Diploma/Trade qualifications	40 (11.2)	15 (13.0)	25 (10.3)	
Bachelor/Masters/PhD	242 (67.6)	68 (59.1)	174 (71.6)	
Current employment condition				
Unemployed/home maker (no source of income)	102 (28.5)	49 (42.6)	53 (21.8)	<0.001
Jobs affected by COVID-19	19 (5.3)	6 (5.2)	13 (5.3)	
Have an income source	237 (66.2)	60 (52.2)	177 (72.8)	
Health conditions and lifestyle characteristics				
Chronic medical conditions				
No	316 (88.3)	98 (85.2)	218 (89.7)	0.217
Yes	42 (11.7)	17 (14.8)	25 (10.3)	
Smoking status				
Never smoker	329 (91.9)	102 (88.7)	227 (93.4)	0.126
Ever smoker	29 (8.1)	13 (11.3)	16 (6.6)	
Current alcohol drinking (in the last 4 weeks)				
No	197 (55.0)	57 (49.6)	140 (57.6)	0.153
Yes	161 (45.0)	58 (50.4)	103 (42.4)	
Perceived physical health status				
Poor/ fair	25 (7.0)	14 (12.2)	11 (4.5)	<0.001
Average	165 (46.1)	65 (56.5)	100 (41.2)	
Good / excellent	168 (46.9)	36 (31.3)	132 (54.3)	
Perceived mental health status				
Poor/ fair	34 (9.5)	18 (15.7)	16 (6.6)	<0.001
Average	152 (42.5)	62 (53.9)	90 (37.0)	
Good / excellent	172 (48.0)	35 (30.4)	137 (56.4)	

Data are presented as frequency (%).
[#]All the p values were computed based on the Pearson chi-square test.

Uptake of COVID-19 vaccination and reasons

Overall, 67.8% (243/358) of the participants had received at least one dose of the COVID-19 vaccine and, among those vaccinated, 74.9% (182/243) had received two doses. Table 2 summarizes the main reasons for vaccination, and the most commonly reported reasons were "desire to protect self" (70.0%) and "desire to protect friends/family" (60.9%). Over half of those not vaccinated (51. 4%) reported low intention (scored 0-3) to get vaccinated in the following 15 days. The most commonly cited reason for their hesitancy was their "concern

about the side effects and safety of the vaccine" (60.0%), followed by a "plan to wait and see if it is safe and may get it later" (51.3%) (see Table 2).

Table 2. Reasons for vaccine uptake and hesitancy

Reasons for getting vaccinated against COVID-19* (N=243)	**n (%)**
Desire to protect self	170 (70.0)
Desire to protect friends/ family	148 (60.9)
Desire to help flatten the curve of disease	123 (50.6)
Desire to travel aboard	101 (41.6)
Compulsory in the workplace	57 (23.5)
Others (Worry about availability of vaccines in the future, study-related requirements, visit elderly homes)	12 (4.9)
Reasons for not getting vaccinated against COVID-19* (N=115)	**n (%)**
Concern about the side effects and safety of the vaccine	69 (60.0)
Plan to wait and see if it is safe and may get it later	59 (51.3)
The vaccine is being developed too quickly	32 (27.8)
Others (chronic disease, pregnant, not understanding self-health, after surgery, allergy, planning)	16 (4.5)
The vaccine will not work	11 (9.6)
Don't like needles	11 (9.6)
The doctor did not recommend me for COVID-19 vaccination	9 (7.8)

* Multiple responses possible

Other information concerning COVID-19 impacts and vaccinations

Table 3 summarises the information concerning COVID-19 impacts and vaccinations. The majority of them (78.2%) perceived the pandemic did not impact their financial situation. Only 7% of them had known or suspected contact(s) with COVID-19 cases, but nearly one-fifth (22.6%) perceived they had been exposed to COVID-19, and 16.4% had a consultation due to COVID-19 related stress in the last six months. About one-third of the participants perceived that they had good or excellent knowledge about COVID-19 (36.6%) and COVID-19 vaccines (34.3%); of which, their sources of knowledge were from the internet (70.7% and 69.8%, respectively) and TV (69.8% and 62.8%, respectively). The figures of source of knowledge and comparison of information sources on COVID-19 by COVID-19 vaccination, and COVID-19 vaccine by COVID-19 vaccination are shown in supplementary file 3.

Table 3. Information concerning COVID-19 impacts and vaccinations.

	Total (N=358)	Vaccinated against COVID-19		p-value#
		No (n =115)	Yes (n =243)	
	n (%)	n (%)	n (%)	
Experience or perceptions related to COVID-19				
COVID-19 impacted the financial situation				
No impact	280 (78.2)	85 (73.9)	195 (80.2)	0.131
Yes, impacted positively	17 (4.7)	4 (3.5)	13 (5.3)	
Yes, impacted negatively	61 (17.0)	26 (22.6)	35 (14.4)	
Contact with known/suspected case of COVID-19				
No	302 (84.4)	105 (91.3)	197 (81.1)	0.017
Yes	25 (7.0)	2 (1.7)	23 (9.5)	
Unsure	31 (8.7)	8 (7.0)	23 (9.5)	
Perceived exposure to COVID-19				
No	277 (77.4)	100 (87.0)	177 (72.8)	0.003
Yes	81 (22.6)	15 (13.0)	66 (27.2)	
Had ever used any healthcare service to overcome COVID-19 related stress in the last six months				
No	303 (84.6)	94 (81.7)	209 (86.0)	0.296
Yes	55 (15.4)	21 (18.3)	34 (14.0)	
Perceived knowledge of COVID-19				
Poor/ fair	20 (5.7)	10 (9.3)	10 (4.1)	<0.001
Average	202 (57.7)	76 (71.0)	126 (51.9)	
Good/ excellent	128 (36.6)	21 (19.6)	107 (44.0)	
Perceived knowledge of COVID-19 vaccine				
Poor/ fair	33 (9.4)	14 (13.1)	19 (7.8)	<0.001
Average	197 (56.3)	75 (70.1)	122 (50.2)	
Good/ excellent	120 (34.3)	18 (16.8)	102 (42.0)	
Reported sources of knowledge about COVID-19*				
Newspapers and magazines				
No	185 (51.7)	65 (56.5)	120 (49.4)	0.207
Yes	173 (48.3)	50 (43.5)	123 (50.6)	
TV				
No	108 (30.2)	36 (31.3)	72 (29.6)	0.747
Yes	250 (69.8)	79 (68.7)	171 (70.4)	
Radio				
No	271 (75.7)	89 (77.4)	182 (74.9)	0.607
Yes	87 (24.3)	26 (22.6)	61 (25.1)	
Internet				
No	105 (29.3)	39 (33.9)	66 (27.2)	0.190
Yes	253 (70.7)	76 (66.10)	177 (72.8)	
Brochures, posters and other printed materials				
No	272 (76.0)	92 (80.0)	180 (74.1)	0.220
Yes	86 (24.0)	23 (20.0)	63 (25.9)	
Healthcare providers	230 (64.2)	86 (74.8)	144 (59.3)	0.004

No	128 (35.8)	29 (25.2)	99 (40.7)	
Yes				
Family members				
No	261 (72.9)	82 (71.3)	179 (73.7)	0.639
Yes	97 (27.1)	33 (28.7)	64 (26.3)	
Friends, neighbours, and colleagues				
No	231 (64.5)	71 (61.7)	160 (65.8)	0.448
Yes	127 (35.5)	44 (38.3)	83 (34.2)	
Reported sources of knowledge about COVID-19 vaccines*				
Newspapers and magazines				
No	219 (61.2)	73 (63.5)	146 (60.1)	0.538
Yes	139 (38.8)	42 (36.5)	97 (39.9)	
TV				
No	133 (37.2)	38 (33.0)	95 (39.1)	0.269
Yes	225 (62.8)	77 (67.0)	148 (60.9)	
Radio				
No	275 (76.8)	89 (77.4)	186 (76.5)	0.859
Yes	83 (23.2)	26 (22.6)	57 (23.5)	
Internet				
No	108 (30.2)	39 (33.9)	69 (28.4)	0.288
Yes	250 (69.8)	76 (66.1)	174 (71.6)	
Brochures, posters and other printed materials				
No	250 (69.8)	90 (78.3)	160 (65.8)	0.017
Yes	108 (30.2)	25 (21.7)	83 (34.2)	
Healthcare providers				
No	247 (69.0)	91 (79.1)	156 (64.2)	0.004
Yes	111 (31.0)	24 (20.9)	87 (35.8)	
Family members				
No	279 (77.9)	88 (76.5)	191 (78.6)	0.658
Yes	79 (22.1)	27 (23.5)	52 (21.4)	
Friends, neighbours, and colleagues				
No	232 (64.8)	70 (60.9)	162 (66.7)	0.284
Yes	126 (35.2)	45 (39.1)	81 (33.3)	

Data are presented as frequency (%).
[#]All the p values were computed based on the Pearson chi-square test.
* Multiple responses possible

Risk perception and self-efficacy

The majority of the participants agreed that COVID-19 was a serious disease (73.8%); their health would be severely affected if they got infected with COVID-19 (65.7%), and they were fearful that they would become infected (58.4%) or be quarantined (58.4%). However, only a few (7.5%) perceived that they or their family members were at risk of COVID-19 infection. More than half of them were confident that they could protect themselves against COVID-19 (64.8%) and that the infection could finally be controlled in Hong Kong (55.7%) (See Table 4).

Table 4. Risk perception and self-efficacy.

Item	All (N=332) n (%)	Vaccinated against COVID-19		p-value#
		No (n=103) n (%)	Yes (n=229) n (%)	
Perceived risk of COVID-19				
1. I think COVID-19 is a serious disease.				
Strongly disagree/disagree/uncertain	87 (26.2)	34 (33.0)	53 (23.1)	0.059
Agree/strongly agree	245 (73.8)	69 (67.0)	176 (76.9)	
2. I think I will get infected with COVID-19.				
Strongly disagree/disagree/uncertain	307 (92.5)	99 (96.1)	208 (91.8)	0.091
Agree/strongly agree	25 (7.5)	4 (3.9)	21 (9.2)	
3. I think my family will get infected with COVID-19.				
Strongly disagree/disagree/uncertain	307 (92.5)	100 (97.1)	207 (91.4)	0.032
Agree/strongly agree	25 (7.5)	3 (2.9)	22 (9.6)	
4. I am fear of getting infected with COVID-19.				
Strongly disagree/disagree/uncertain	138 (41.6)	42 (40.8)	96 (41.9)	0.845
Agree/strongly agree	194 (58.4)	61 (59.2)	133 (58.1)	
5. I am fearful of getting quarantined if I get infected.				
Strongly disagree/disagree/uncertain	138 (41.6)	43 (41.7)	95 (41.5)	0.964
Agree/strongly agree	194 (58.4)	60 (58.3)	134 (58.5)	
6. My health will be severely affected if I get infected with COVID-19.				
Strongly disagree/disagree/uncertain	114 (34.3)	39 (37.9)	75 (32.8)	0.364
Agree/strongly agree	218 (65.7)	64 (62.1)	154 (67.2)	
7. I will not go to the hospital even if I get sick because of the risk of getting infected with COVID-19.				
Strongly disagree/disagree/uncertain	290 (87.3)	88 (85.4)	202 (88.2)	0.482
Agree/strongly agree	42 (12.7)	15 (14.6)	27 (11.8)	
Perceived self-efficacy in controlling COVID-19				
1. I believe I can protect myself against COVID-19.				
Strongly disagree/disagree/uncertain	117 (35.2)	45 (43.7)	72 (31.4)	0.031
Agree/strongly agree	215 (64.8)	58 (56.3)	157 (68.6)	
2. I believe COVID-19 can finally be successfully controlled.				
Strongly disagree/disagree/uncertain	147 (44.3)	51 (49.5)	96 (41.9)	0.198
Agree/strongly agree	185 (55.7)	52 (50.5)	133 (58.1)	
3. I have confidence that Hong Kong can win the battle against COVID-19.				
Strongly disagree/disagree/uncertain	142 (42.8)	43 (41.7)	99 (43.2)	0.800
Agree/strongly agree	190 (57.2)	60 (58.3)	130 (56.8)	

Data are presented as frequency (%).
#All the p values were computed based on the Pearson chi-square test.

Factors associated with uptake of COVID-19 vaccination

From the bivariate analyses (Tables 1, 3 & 4), the uptake of COVID-19 vaccination was associated with current employment condition (p<0.001), perceived health status (p<0.001), perceived mental health status (p<0.001), contact with the known suspected case(s) of COVID-

19 (p<0.017), perceived exposure to COVID-19 (p=0.003), perceived knowledge of COVID-19 (p<0.001), perceived knowledge of COVID-19 vaccines (p<0.001), healthcare providers as a source of knowledge about COVID-19 (p=0.004), healthcare providers (p=0.017), and brochures, posters, and other printed materials (p=0.004) as sources of knowledge about COVID-19 vaccines, perception about family members being at risk of COVID-19 infection (p=0.032), and confidence in protecting themselves against COVID-19 (p=0.031).

The results from backward multivariable logistic regression analysis (see Table 5) revealed that the participants whose jobs were affected by COVID-19 (OR=4.83, 95% CI:1.18-19.76), had an income source (OR=2.10, 95% CI:1.18–3.72), perceived good/excellent physical health status (OR=5.09, 95% CI:1.17–22.08), perceived exposure to COVID-19 (OR=2.69, 95% CI:1.28–5.65), perceived to have good/ excellent knowledge of COVID-19 (OR=2.65, 95% CI:1.43–4.93), reported learning about COVID-19 vaccines from brochures, posters and other printed materials (OR=1.95, 95% CI:1.05-3.63), and perceived their family was at risk of COVID-19 infection (OR=4.02, 95% CI:1.08-14.87) were positively associated with vaccination uptake. Alternatively, those who reported learning about COVID-19 from the internet were less likely to receive a COVID-19 vaccine (OR=0.50, 95% CI:0.26-0.98).

Table 5. Factors associated with the uptake of COVID-19 vaccination.

Factors retained in backward logistic regression analysis †	Odds ratio (95% CI)	p-value
Socio-demographic characteristics		
Current employment condition		
Unemployed/home maker (no source of income) (ref)	1	
Jobs affected by COVID-19	4.83 (1.18 – 19.76)	0.029
Have an income source	2.10 (1.18– 3.72)	0.011
Health conditions and lifestyle characteristics		
Perceived physical health status		
Poor/ fair (ref)	1	
Average	3.17 (0.80 – 12.63)	0.101
Good/ excellent	5.09 (1.17 – 22.08)	0.030
Perceived mental health status		
Poor/ fair (ref)	1	
Average	1.47 (0.49 – 4.38)	0.490
Good/ excellent	3.23 (0.99 – 10.53)	0.052
Experience or perceptions related to COVID-19		
Perceived exposure to COVID-19		
No (ref)	1	

Yes	2.69 (1.28 – 5.65)	0.009
Perceived knowledge of COVID-19		
Poor/ fair	1.12 (0.28 – 4.53)	0.875
Average (ref)	1	
Good/ excellent	2.65 (1.43– 4.93)	0.002
Sources of knowledge		
Reported internet as a source of knowledge about COVID-19		
No	1	
Yes	0.50 (0.26 – 0.98)	0.045
Reported brochures, posters and other printed materials as sources of knowledge about COVID-19 vaccines		
No	1	
Yes	1.95 (1.05 – 3.63)	0.035
Perceived risk of COVID-19		
I think my family will get infected with COVID-19.		
Strongly disagree/disagree/uncertain	1	
Agree/strongly agree	4.02 (1.08 – 14.87)	0.037

† Significant factors retained from backward multivariable logistic regression analysis using the variables as listed in Tables 1, 3&4 with p-value <0.25 in the univariate analysis as candidate independent variables
CI: confidence interval; ref: reference category of the categorical independent variable

DISCUSSION

To our knowledge, this study is one of the few studies that explored the factors influencing actual vaccination uptake during the COVID-19 pandemic among community members in Hong Kong and worldwide. In our study, approximately 70% of the sample received at least one dose of the vaccine, which is higher than the officially announced vaccination uptake rate (~50%)[10] and reported in two local cross-sectional studies during the same study period[22,23]. Despite the high vaccination uptake, half of the unvaccinated respondents indicated that the willingness to be vaccinated in the next 15 days was low, revealing a considerable level of vaccine hesitancy in our sample. This finding echoed with other local public health studies[22,23] in which the main concerns reported by unvaccinated people were the side effects and safety of available vaccines. This was also a well-recognized or commonly cited reason for vaccine hesitancy reported consistently in different countries[13-15,21-23,25-26]. This implies that further efforts in public education should focus on conveying scientific evidence and knowledge about the efficacy and safety of various available vaccines to enhance their evidence-based decision-making on vaccination.

Among various socio-demographic factors, employment condition was found to be an independent determinant of vaccination uptake. Specifically, those who were unemployed or homemaker were less likely to be vaccinated than those who were working or who had their employment affected by the COVID-19 pandemic. As an increasing number of employers adopted vaccination instead of regular testing approaches proposed by the (local) government, unvaccinated employees would require to undergo self-financed COVID-19 testing every two weeks[27]. Such testing requirements may encourage more employees or job seekers to get vaccinated. Similarly, a recent international study found that unemployed people but not seek a job reported a lower intention to be vaccinated[13]. This suggests that vaccination campaigns may effectively highlight vaccination's financial or economic benefits to the working population (such as resuming normal business conditions and more job opportunities). Nevertheless, efforts should also be made to promote the various benefits of vaccination to the non-working population, such as a gradual return to normal life after achieving herd community.

This study identified several knowledge-related factors influencing vaccination uptake. In the bivariate analysis, both perceived knowledge of COVID-19 and its vaccines were associated with vaccination uptake, but only perceived knowledge of COVID-19 remained a significant factor in the multivariable model. Likewise, a recent British population-based survey showed that the perception of sufficient information/knowledge about COVID-19 and the vaccine was positively correlated with the intention to vaccinate[15]. Regarding information sources, our study found that those who learned about the COVID-19 vaccines through brochures, posters, and other printed materials were more likely to receive the vaccine. Interestingly, those who reported that they learned from the internet were less likely to be vaccinated. One possible explanation for these findings is that printed materials are more likely to be produced by authoritative bodies (e.g., Department of Health[28]) based on the latest

scientific evidence. At the same time, the internet is often fueled by the spread of inaccurate information (i.e., an infodemic in which health information was mixed with fear, speculation and rumor, amplified swiftly worldwide by technologies such as the internet)[29;] whereas, higher news consumption through social media was associated with lower levels of knowledge and more fake news belief[30]. Previous study also revealed that fake news led healthcare professionals to get information from accurate and reliable source[31]. In this regard, a recent randomized controlled trial in the United Kingdom and the United States suggested that exposure to online misinformation can reduce the public's intention to vaccinate[18].

In line with the finding that protecting friends and family is the major reason for vaccination, we found that individuals who perceived their family members were at risk of contracting COVID-19 were more likely to be vaccinated than those who have not reported this perception. Similarly, several reports show that consideration of others, particularly family members, regarding the threat of COVID-19 affects vaccination intention[13,15,18,21]. Taken together, these results suggest that vaccination promotion messages should emphasize the generous benefits of vaccination to significant others and society at large, for example, the effectiveness of vaccination in reducing the infection risk at individual and collective levels[32].

In this study, people's perceived COVID-19 exposure independently predicted their vaccination uptake. To our knowledge, this factor has not been reported as a predictor of vaccination intention or acceptance in previous studies. It can be speculated that those who perceive that they have not been exposed to the COVID-19 may not feel the urgency of vaccination, leading to vaccine hesitancy.

Notably, the final regression model was perceived to have good/excellent physical health status was the strongest factor for vaccination uptake. Likewise, this factor has been found to predict the intention of vaccination against COVID-19 among the general population in China[26]. and actual vaccination uptake in a sample of the elderly population in Germany[17]. It could be

possible that people who perceive they were in poor health might be more worried about the vaccine's side effects, which would become a major obstacle to vaccination.

Limitations

This study has several limitations. First, this study adopted a cross-sectional design so that the causality between vaccination uptake and other variables could not be determined. Second, a non- random sample was used; and this might lead to selection bias and limit the generalizability of the findings. Third, the sample was found to be over-represented by female, highly educated and younger adults, so caution is needed to be taken when generalizing the findings to the general population in Hong Kong. Finally, self-report questionnaires might also be subject to social desirability bias and inaccurate understanding and responses to the questionnaire, thereby reducing the reliability and validity of the findings.

CONCLUSION

This study is one of the few survey studies to explore the reasons and factors associated with the 'actual' vaccination uptake among the general population during the COVID-19. The results provide evidence and insights for formulating effective strategies to promote COVID-19 vaccination in Hong Kong and other developed countries.

Acknowledgments

The authors would like to thank all the participants in the study.

Contributors

CLW and WTC contributed to the study's conception and design. CLW was involved in gaining ethical approval. CLW involved in data collection. CLW, AWYL and OMHC analyzed the data and wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Funding

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

Competing interests

The authors declare that there is no conflict of interest.

Patient consent for publication

Not required.

Ethics approval

This study was approved by the Survey and Behavioural Research Committee of The Chinese University of Hong Kong (SBRE-20-784).

Provenance and peer review

Not commissioned; externally peer-reviewed.

Data availability statement

The anonymous data which form the basis for this study are available from the authors on reasonable request.

REFERENCES

1. Coronavirus Resource Center. COVID-19 Dashboard, https://coronavirus.jhu.edu/map.html (2021, accessed August 31 2021).
2. The Government of Hong Kong Special Administrative Region. Together,We Fight the Virus! https://www.coronavirus.gov.hk/eng/index.html (2021, accessed August 31 2021).
3. Altig D, Baker S, Barrero JM, et al. Economic uncertainty before and during the COVID-19 pandemic. *J Public Econ* 2020;191:104274. https://doi.org/10.1016/j.jpubeco.2020.104274.
4. Wu T, Jia X, Shi H, et al. Prevalence of mental health problems during the COVID-19 pandemic: a systematic review and meta-analysis. *J Affect Disord* 2021;281:91-8. https://doi.org/10.1016/j.jad.2020.11.117.
5. World Health Organization. COVID-19 advice for the public: getting vaccinated, https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines/advice (2021, accessed August 31 2021).
6. Kwok KO, McNeil EB, Tsoi MTF, et al. Will achieving herd immunity be a road to success to end the COVID-19 pandemic? *J Infect* 2021; 83:381-412. https://doi.org/10.1016/j.jinf.2021.06.007.
7. Kwok KO, Lai F, Wei WI, et al. Herd immunity-estimating the level required to halt the COVID-19 epidemics in affected countries. *J Infect* 2020;80(6):e32-e3. https://doi.org/10.1016/j.jinf.2020.03.027.
8. World Health Organization. Report of the SAGE Working Group on Vaccine Hesitancy, http://www.who.int/immunization/sage/meetings/2014/october/SAGE_working_group_revised_report_vaccine_hesitancy.pdf (2015, accessed August 19 2021).

9. World Health Organization. Ten threats to global health in 2019, https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019 (2021, accessed August 19 2021).

10. The Government of Hong Kong Special Administrative Region. COVID-19 vaccination programme, https://www.covidvaccine.gov.hk/en/ (2021 accessed August 19 2021).

11. The Government of Hong Kong Special Administrative Region. Early Vaccination for All" campaign launched, https://www.info.gov.hk/gia/general/202105/31/P2021053100749.htm (2021 May 31, accessed August 19 2021).

12. news.gov.hk. Early vaccination urged, https://www.news.gov.hk/eng/2021/07/20210718/20210718_131218_995.html (2021 July 18, accessed August 19 2021).

13. Burke PF, Masters D, Massey G. Enablers and barriers to COVID-19 vaccine uptake: an international study of perceptions and intentions. *Vaccine* 2021;39(36):5116-28. https://doi.org/10.1016/j.vaccine.2021.07.056.

14. Soares P, Rocha JV, Moniz M, et al. Factors associated with COVID-19 vaccine hesitancy. *Vaccines* 2021;9(3):300. https://doi.org/10.3390/vaccines9030300.

15. Sherman SM, Smith LE, Sim J, et al. COVID-19 vaccination intention in the UK: results from the COVID-19 vaccination acceptability study (CoVAccS), a nationally representative cross-sectional survey. *Hum Vaccin Immunother* 2021;17(6):1612-21. https://doi.org/1080/21645515.2020.1846397.

16. Viswanath K, Bekalu M, Dhawan D, et al. Individual and social determinants of COVID-19 vaccine uptake. *BMC Public Health*. 2021;21(1):818. https://doi.org/10.1186/s12889-021-10862-1.

17. Malesza M, Wittmann E. Acceptance and intake of COVID-19 vaccines among older Germans. *J Clin Med* 2021;10(7). https://doi.org/10.3390/jcm10071388.

18. Loomba S, de Figueiredo A, Piatek SJ, et al. Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. *Nat Hu Behav* 2021;5(3):337-48. https://doi.org/10.1038/s41562-021-01056-1.

19. Wong MCS, Wong ELY, Huang J, et al. Acceptance of the COVID-19 vaccine based on the health belief model: a population-based survey in Hong Kong. *Vaccine* 2021;39(7):1148-56. https://doi.org/10.1016/j.vaccine.2020.12.083.

20. Kwok KO, Li KK, Tang A, et al. Psychobehavioral responses and likelihood of receiving COVID-19 vaccines during the pandemic, Hong Kong. *Emerg Infect Dis* 2021;27(7):1802-10. https://doi.org/10.3201/eid2707.210054.

21. Yılmaz M, Sahin MK. Parents' willingness and attitudes concerning the COVID-19 vaccine: A cross-sectional study. *Int J Clin Prac*t 2021;75(9):e14364. https://doi:10.1111/ijcp.14364

22. The Chinese University of Hong Kong. Survey findings on views about COVID-19 released by Hong Kong Institute of Asia-Pacific Studies at CUHK, https://www.cpr.cuhk.edu.hk/en/press/survey-findings-on-views-about-covid-19-released-by-hong-kong-institute-of-asia-pacific-studies-at-cuhk-6/ (2021 August 4, accessed August 10 2021).

23. The Baptist University of Hong Kong. Vaccine Hesitancy Study Reports, https://research.hkbu.edu.hk/highlighted-projects/overcoming-vaccine-hesitancy-in-hong-kong#Reports (2021, accessed August 20 2021).

24. Wong CL, Chen J, Chow KM, et al. Knowledge, attitudes and practices towards COVID-19 amongst ethnic minorities in Hong Kong. *Int J Environ Res Public Health* 2020;17(21): 7878. https://doi.org/10.3390/ijerph17217878.

25. Wang K, Wong EL, Ho K-F, et al. Change of willingness to accept covid-19 vaccine and reasons of vaccine hesitancy of working people at different waves of local epidemic in Hong Kong, China: repeated cross-sectional surveys. *Vaccines* 2021;9(1). https://doi.org/10.3390/vaccines9010062.

26. Wang J, Zhang Y, Long S, et al. Non-EPI vaccine hesitancy among Chinese adults: a cross-sectional study. *Vaccines* 2021;9(7). https://doi.org/10.3390/vaccines9070772.

27. The Government of Hong Kong Special Administrative Region. Government tightens eligibility criteria for free COVID-19 testing for targeted groups at community testing centres, https://www.info.gov.hk/gia/general/202108/04/P2021080401030.htm (2021 August 4, accessed August 20 2021).

28. Hong Kong Department of Health. Health Education Materials, https://www.chp.gov.hk/en/features/102745.html (2021, accessed August 31 2021).

29. Eysenbach G. Infodemiology: the epidemiology of (mis)information. *Am J Med* 2002;113(9):763-5. https://doi.org/10.1016/S0002-9343(02)01473-0

30. Gerosa T, Gui M, Hargittai E, et al. (Mis)informed during COVID-19: how education level and information sources contribute to knowledge gaps. *Int J Commun* 2021;15:2196-217.

31. Kaplan AK, Sahin MK, Parildar H, Adadan Guvenc I. The willingness to accept the COVID-19 vaccine and affecting factors among healthcare professionals: A cross-sectional study in Turkey. *Int J Clin Pract* 2021;75(7):e14226. https://doi:10.1111/ijcp.14226

32. Barello S, Palamenghi L, Graffigna G. Looking inside the 'black box' of vaccine hesitancy: unlocking the effect of psychological attitudes and beliefs on COVID-19 vaccine acceptance and implications for public health communication. *Psychol Med* 2021; Epub 2021/03/08. https://doi.org/10.1017/S003329172100101X

Factors influencing COVID-19 vaccination uptake among community members in Hong Kong: a cross-sectional online survey

Background: The continued spread COVID-19 in Hong Kong poses a significant impact on community members. Vaccination is recognised to be the most effective approach to contain the spread of the COVID-19 pandemic in a long run. However, the vaccination uptake in Hong Kong is still suboptimal. Little is known about the factors that influence COVID-19 vaccination uptake among the general public in Hong Kong.

Purpose: To examine factors that affect actual COVID-19 vaccination uptake among community members in Hong Kong.

Design: A cross-sectional design.

Methods: A total of 340 community members will be recruited online. A set of self-developed questionnaire will be used to assess sociodemographic characteristics, vaccination status, perceived impact of COVID-19, and their attitudes towards COVID-19.

Data analysis: Quantitative data analysis will be conducted.

Potential significance: The findings are imperative to inform strategies to increase COVID-19 vaccination rates in Hong Kong.

Introduction

Coronavirus disease 2019 (COVID-19) is an emerging respiratory disease caused by a novel coronavirus (Wang et al., 2020). The disease was first discovered in Wuhan, Hubei Province in December 2019 (Bai et al., 2020). The ongoing COVID-19 pandemic has spread quickly, with confirmed cases having been reported in the majority of countries worldwide. The World Health Organisation (WHO) declared the disease a public health emergency of international concern on January 30 and called on all countries to work together to prevent the worsening of the pandemic (WHO, 2020). Some unprecedented restrictive measures have been implemented in several countries to contain its spread, including strict "lock down" regulations, closing of premises and public places, compulsory quarantine measures, and isolation care for infected persons and suspected cases. As of April 6, 2021, statistics on the WHO Coronavirus Disease (COVID-19) Dashboard show that the virus has spread to 221 countries, with approximately 131.02 million confirmed cases and over 2.85 million deaths (WHO, 2021a). Compared with other countries in the world, Hong Kong is moderately affected by the COVID-19 pandemic, but is being struck with the fourth wave of COVID-19 in recent days. Since the outbreak, a total of 11,532 COVID-19 cases have been recorded, of which 205 people have died of this disease (Centre for Health Protection, 2021).

Vaccination is one of the most effective ways to prevent further morbidity and mortality and to promote herd immunity. As of February 18, 2021, at least seven different COVID-19 vaccines have been launched on three platforms in different countries, including inactivated or weakened virus vaccines, protein-based vaccines, viral vector vaccines, and RNA and DNA vaccines (WHO, 2021b). In Hong Kong, a territory-wide COVID-19 Vaccination Programme free of charge and on a voluntary basis for all eligible residents has been implemented by the Hong Kong government to protect members of public against COVID-19. Two intramuscular administered COVID-19 vaccines have been authorized for use: Inactivated (CoronaVac) and COMIRNATYTM COVID-19 mRNA Vaccine (BNT162b2) (COMIRNATY). Individuals are required to receive two doses of the same vaccine to build up adequate protection. As of 5 April 2021, about 487,000 Hong Kong people have been vaccinated for 1st dose, and 90,200 have fully vaccinated (The Government of Hong Kong Special Administrative Region, 2021). Nevertheless, herd immunity against COVID-19 requires at least 70% of population to be vaccinated. The slow vaccination progress calls for more effective strategies to overcome barriers.

Emerging epidemiological evidence suggests a broad array of factors that may affect vaccination intention among the general public, including sociodemographic factors such as

age (Sherman et al., 2021; Soares et al., 2021) and employment status (Soares et al., 2021); disease-specific factors such as risk perception (Malesza & Wittmann, 2021; Sherman et al., 2021;) and COVID-19 information exposure (Loomba, de Figueiredo, Piatek, de Graaf, & Larson, 2021; Malesza & Wittmann, 2021; Sherman et al., 2021; Soares et al., 2021;) and vaccine-specific factors such as confidence in efficacy and safety (Malesza & Wittmann, 2021; Sherman et al., 2021; Soares et al., 2021; Wong et al., 2021) and vaccination attitudes (Sherman et al., 2021). However, the major factors influencing actual vaccine uptake have seldom been explored. A recent cross-sectional study on 1,037 older Germans suggested that general health condition, the presence of chronic conditions, perceptions of infection, the severity of potential long-term effects, the efficacy of vaccines, the benefits of vaccination, the negative side-effects of vaccines and the general impediments to vaccination were the factors influencing actual vaccination (Malesza & Wittmann, 2021).

Existing studies on vaccination intentions are largely conducted prior to the commencement of the worldwide mass vaccination programmes. As far as we know, there is no known information about the factors influencing actual vaccination uptake. Therefore, the novelty of this study is to examine the factors that affect actual vaccination uptake among community members of Hong Kong.

Methods

Study design

This study uses a cross-sectional design.

Setting and sample

Participants will be recruited online. To be eligible to participate in this study, potential community members are (1) 18 years of age or older; (2) able to communicate in Chinese or English. Participants who suffer from cognitive impairment or self-disclose of having major depressive disorder will be excluded. The sample size is determined to allow adequate precision to estimate the COVID-19 vaccination rate. By using the power analysis software, PASS 16.0 (NCSS, Kaysville, US), it is estimated that a sample size of n=340 participants would allow the study to estimate the uptake rate with a margin of error of at most ±5% at a level of significance of 0.05 on the basis of an anticipated uptake rate of around one-third.

For the online survey, an online survey portal will be created using SurveyMonkey, a secure cloud-based online survey platform. The brief study description, consent forms and questionnaires will be included in the online survey portal. Participants will be invited to

participate the study via convenience and snowball sampling methods. Participants will be responded to the invitation by clicking a link that direct them to the online survey portal. They will be asked to click the "yes" button to indicate their consent to the study and complete the socio-demographics and background information as well as a set of self-developed questionnaire online.

Survey Instrument

A set of questionnaires comprised of three sections is developed by the research team with references to previous studies of similar topics (Malesza & Wittmann, 2021; Soares et al., 2021;Wong et al., 2020). The questionnaire has been reviewed by a panel of experts and will be validated with 20 participants representing the target population before the main study for their understanding of the questionnaire content before the main study.

The questionnaire consists of three sections that aim to collect the following information from the participants:

1. Participants' socio-demographic characteristics, health conditions and lifestyle characteristics, including age, gender, place of birth, living status, marital status, highest educational qualification, current employment condition, co-morbidities, smoking and alcohol drinking status, perceived physical and mental health status.
2. Vaccination status and perceived impact of COVID-19: uptake of COVID-19 vaccination (yes/no), reasons for/against vaccination (an open-ended question), impact of COVID-19 on financial situation, contact with known/suspected cases of COVID-19, perceived COVID-19 exposure, perceived knowledge of COVID-19 and COVID-19 vaccines, sources of information about COVID-19 and COVID-19 vaccines, healthcare service used to overcome COVID-19 related stress in the past six months.
3. Attitudes towards COVID-19: a 10-item questionnaire developed by the research team (Wong et al., 2020). The questionnaire comprises two subscales: perceived risk of COVID-19 (7 items) and perceived self-efficacy in controlling COVID-19 (3 items). Each item is rated on a 5-point Likert scale (from 1='strongly disagree' to 5='strongly agree'.

Statistical analysis

IBM SPSS Statistics for Windows version 25.0 (IBM Corp., Armonk, NY, USA) will be used for statistical analysis. For the online questionnaire responses, they will be downloaded, coded and input into the SPSS. Descriptive statistics, such as mean and standard deviations

(SD) for continuous variables and proportions for categorical variables, will be used to summarize outcome variables as well as participants' demographics characteristics. These characteristics will be compared between the participants who had vaccinated (at least one dose) and those who had not, using Pearson's chi-square test. Those factors showing significance ($p < 0.25$) in bivariate analyses will be selected as candidate variables for backward multivariable logistic regression analysis to delineate factors significantly associated with their vaccination status. The statistical significance level is set at $p < 0.05$ (two-sided).

Ethical consideration

Ethical approval will be obtained from the Chinese University of Hong Kong's Survey and Behavioural Research Committee. All study procedures involving human participants will be handled in accordance with the Helsinki Declaration. The participants will be assured that their participation is voluntary, their rights to withdraw at any time will be upheld and their information will be confidential. All information will be kept safely in a locked file that could only be accessed by the researcher. All data will be destroyed six months after the project has completed.

Significance of the study

This study is one of the few survey studies aims at exploring the reasons and factors associated with the 'actual' vaccination uptake among general population during the COVID-19. The results will provide evidence and insights for formulating effective strategies to promote COVID-19 vaccination in Hong Kong and other developed countries.

References

Bai, Y., Yao, L., Wei, T., Tian, F., Jin, D. Y., Chen, L., Wang, M. (2020). Presumed asymptomatic carrier transmission of COVID-19. *JAMA, 323*(14), 1406-1407.

Centre for Health Protection, Hong Kong. (2021, April 6). *Latest Situation of Novel Coronavirus infection in Hong Kong.* https://www.coronavirus.gov.hk/eng/index.html

Loomba, S., de Figueiredo, A., Piatek, S. J., de Graaf, K., & Larson, H. J. (2021). Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. *Nature Human Behaviour, 5*(3), 337-348.

Malesza, M., & Wittmann, E. (2021). Acceptance and intake of COVID-19 vaccines among older Germans. *Journal of Clinical Medicine, 10*(7).

Sherman, S. M., Smith, L. E., Sim, J., Amlôt, R., Cutts, M., Dasch, H., . . . Sevdalis, N. (2021). COVID-19 vaccination intention in the UK: results from the COVID-19 vaccination acceptability study (CoVAccS), a nationally representative cross-sectional survey. *Human Vaccines & Immunotherapeutics, 17*(6), 1612-1621.

Soares, P., Rocha, J. V., Moniz, M., Gama, A., Laires, P. A., Pedro, A. R., . . . Nunes, C. (2021). Factors associated with COVID-19 vaccine hesitancy. *Vaccines, 9*(3), 300. doi:10.3390/vaccines9030300

The Government of the Hong Kong Special Administrative Region. (2021, 6 April). Vaccination Dashboard. https://www.covidvaccine.gov.hk/en/dashboard

Wang, C., Horby, P. W., Hayden, F. G., & Gao, G. F. (2020). A novel coronavirus outbreak of global health concern. *Lancet, 395*(10223), 470-473.

Wong, C. L., Chen, J., Chow, K. M., Law, B. M. H., Chan, D. N. S., So, W. K. W., Leung, a W. Y., & Chan, C. W. H. (2020). Knowledge, attitudes and practices towards COVID-19 amongst ethnic minorities in Hong Kong. International Journal of Environmental Research and Public Health, 17(21), 7878.

Wong, M. C. S., Wong, E. L. Y., Huang, J., Cheung, A. W. L., Law, K., Chong, M. K. C., . . . Chan, P. K. S. (2021). Acceptance of the COVID-19 vaccine based on the health belief model: A population-based survey in Hong Kong. Vaccine, 39(7), 1148-1156.

World Health Organizatio (2020, January 31). *2019-nCoV outbreak is an emergency of international concern.* https://www.euro.who.int/en/health-topics/health-emergencies/pages/news/news/2020/01/2019-ncov-outbreak-is-an-emergency-of-international-concern

World Health Organization (2021a, April 6). *WHO Coronavirus Disease (COVID-19) Dashboard.* https://covid19.who.int

World Health Organization (2021b, March 19). *COVID-19 vaccines* https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines

The Chinese University of Hong Kong
Faculty of Medicine
The Nethersole School of Nursing

For office use only:

Date：_____

Code no.：_____

Factors influencing COVID-19 vaccination uptake among community members in Hong Kong: a cross-sectional online survey

Questionnaires - English version

Part 1. Socio-demographics and background information:

1. Age: _____ (in years)

2. Gender:
☐ Male
☐ Female

3. Place of birth:
☐ Hong Kong
☐ Mainland China
☐ Others, please specify: _____

4. Living status:
☐ Live without family members
☐ Live with family members

5. Marital status:
☐ Single, divorced, widowed
☐ Cohabiting, Married

6. Highest educational/vocational qualification:
☐ Primary/Grade 1 to 6
☐ Secondary/Higher Secondary/Grade 7 to 12
☐ Certificate/Diploma/Trade qualifications
☐ Bachelor/Masters/PhD

7. Current employment condition:
☐ Unemployed/Housewife/Home maker/Home duties (No source of income)
☐ Jobs affected by COVID-19 (lost job/working hours reduced/afraid of job loss)
☐ Have an income source (employed/Government benefits)

8. COVID-19 impacted the financial situation:
☐ No impact
☐ Yes, impacted positively
☐ Yes, impacted negatively

9. Chronic medical condition:
☐ No
☐ Yes, please specify_____

10. Smoking:
☐ Never smoker
☐ Ever smoker (Daily/Non-daily/Ex)

11. Increased smoking over the last 6 months:
☐ No
☐ Yes

12. Current alcohol drinking (last 4 weeks):
☐ No
☐ Yes

13. Increased alcohol drinking over the last 6 months:
☐ No
☐ Yes

14. Contact with known/suspected cases of COVID-19:
☐ No
☐ Unsure
☐ Yes, indirect contact
☐ Yes, provided direct care

15. Experience related to COVID-19 pandemic (multiple response possible):
☐ No known exposure to COVID-19
☐ Tested positive for COVID-19
☐ Tested negative for COVID-19
☐ Had recent overseas travel history and was in quarantine

16. Perceived physical health status:
☐ Poor
☐ Fair
☐ Average
☐ Good
☐ Excellent

17. Perceived mental health status:
☐ Poor
☐ Fair
☐ Average
☐ Good
☐ Excellent

18. Healthcare service use related to COVID-19 in the last six months:
☐ No
☐ Consulted a GP
☐ Consulted a Psychologist
☐ Consulted a Psychiatrist
☐ Used specialised mental healthcare settings
☐ Use mental health resources
☐ Use mental health resources available through media
☐ Use mental health support services
☐ Use combination of services

19. Where did you learn about COVID-19? (multiple response possible)
☐ Newspapers and magazines
☐ TV
☐ Radio
☐ Internet
☐ Brochures, posters and other printed materials
☐ Healthcare providers
☐ Family members
☐ Friends, neighbours, and colleagues

☐ Others, please specify _____

20. How would you rate your knowledge level on COVID-19?
☐ Poor
☐ Fair
☐ Average
☐ Good
☐ Excellent

21. Where did you learn about COVID-19 vaccines? (multiple response possible)
☐ Newspapers and magazines
☐ TV
☐ Radio
☐ Internet
☐ Brochures, posters and other printed materials
☐ Healthcare providers
☐ Family members
☐ Friends, neighbours, and colleagues
☐ Others, please specify _____

22. How would you rate your knowledge level on COVID-19 vaccine?
☐ Poor
☐ Fair
☐ Average
☐ Good
☐ Excellent

23. Have you vaccinated against COVID-19:
☐ Yes, taken 1st dose (CoronaVac)
☐ Yes, taken 1st dose (Comirnaty)
☐ Yes, completed two doses (CoronaVac)
☐ Yes, completed two doses (Comirnaty)
☐ No (please go to question 27 and question 28)

24. Where have you been vaccinated against COVID-19 in the past 15 days:
☐ Community Vaccination Centres
☐ Designated general outpatient clinics (GOPCs) of the Hospital Authority
☐ Designated private clinics
☐ Residential care homes and nursing homes
☐ Designated clinics of the Department of Health (DH)

25. Reasons for vaccinate against COVID-19:
☐ Desire to help flatten the curve of disease
☐ Desire to protect self
☐ Desire to protect friends/ family
☐ Desire to travel aboard
☐ Compulsory in the workplace
☐ Others, please specify _____

26. Reasons for choosing the COVID-19 vaccine from the available types: _____

27. Reasons for not vaccinate against COVID-19: _____
☐ Concern about the side effects and safety of the vaccine
☐ The vaccine is being developed too quickly
☐ Plan to wait and see if it is safe and may get it later
☐ The doctor did not recommended me for COVID-19 vaccination
☐ The vaccine will not work
☐ Don't like needles

☐ Others, please specify _____

28. How likely you will take the COVID-19 vaccine in the next 15 days?

0 (definitely no) 10 (definitely yes)

Part 2. Attitudes towards COVID-19

Please select the answer depending on how much you agree with the statements.

	Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
3.1 I think COVID-19 is a serious disease.					
3.2 I think I will get infected with COVID-19.					
3.3 I think my family will get infected with COVID-19.					
3.4 I am fear of getting infected with COVID-19.					
3.5 I am fearful of getting quarantined if I get infected.					
3.6 My health will be severely affected if I get infected with COVID-19.					
3.7 I will not go to the hospital even if I get sick because of the risk of getting infected with COVID-19.					
3.8 I believe I can protect myself against COVID-19.					
3.9 I believe COVID-19 can finally be successfully controlled.					
3.10 I have confident that Hong Kong can win the battle against COVID-19.					

-THE END-

- THANK YOU FOR YOUR PARTICIPATION-

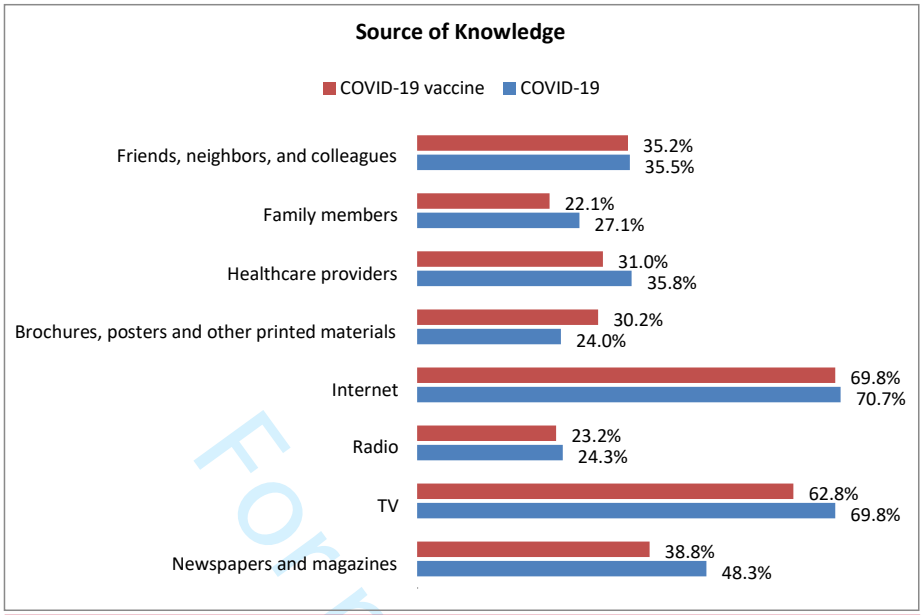

Figure 1 Source of knowledge about COVID-19 and COVID-19 vaccine

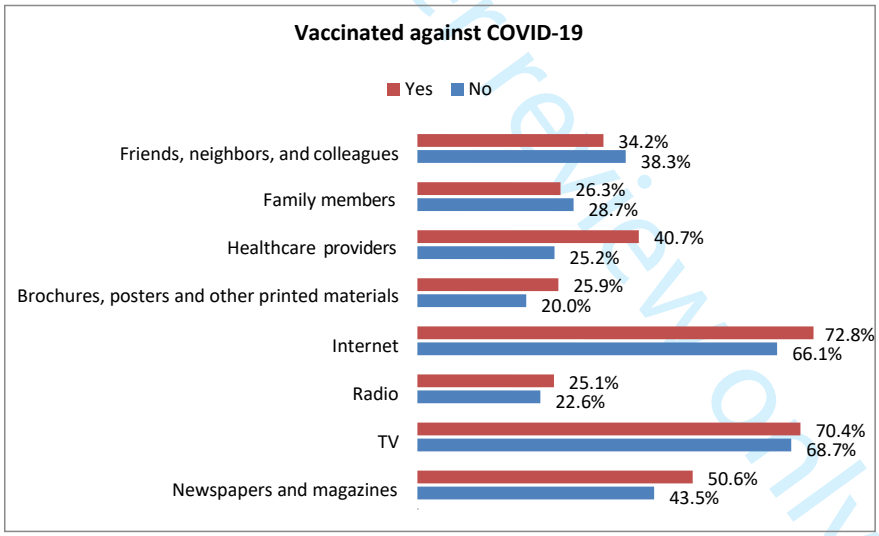

Figure 2 Comparison of information sources on COVID-19 by COVID-19 vaccination

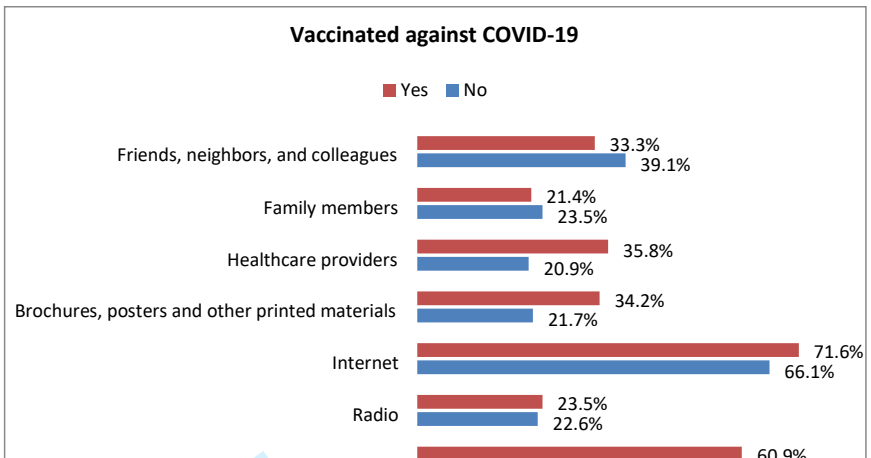

Figure 3 Comparison of information sources on COVID-19 vaccine by COVID-19 vaccination

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7-8*
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	10-14

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	14-15
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.