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Influenza vaccine uptake, COVID-19 vaccination intention and vaccine hesitancy among nurses: A survey

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ABSTRACT

Background: A healthy healthcare system requires healthy healthcare workers. Protecting healthcare workers including nurses against COVID-19 is crucial, and vaccination could be a viable future option. However, vaccine hesitancy remains a global challenge. Nurses, as a trustworthy and creditable source of vaccine-related information, may build public confidence in vaccination. Hence, research on vaccine hesitancy among nurses is warranted.

Objectives: This study estimated nurses' influenza vaccination behaviors and intention to receive COVID-19 vaccine when available, and examined their corresponding 5C psychological antecedents (confidence, complacency, constraints, calculation, and collective responsibility). To investigate the impact of COVID-19-related work demands, the mediation effects of work stress on the association between work demands and COVID-19 vaccination intention were also examined.

Design: Cross-sectional online survey

Settings: Nurses were invited to participate via the promotion of a professional nursing organization and by personal referrals during the COVID-19 outbreak in Hong Kong between mid-March and late April 2020.

Participants: 1,205 eligible nurses (mean age = 40.79, *SD* = 10.47; 90% being female) were included in the analyses.

Methods: Demographics, influenza vaccination, intention to have COVID-19 vaccine, the 5C vaccine hesitancy components, work stress and COVID-19-related work demands (insufficient supply of personal protective equipment, involvement in isolation rooms, and unfavorable attitudes towards workplace infection control policies) were reported in the survey.

Results: The influenza vaccine uptake rate and the proportion intending to take COVID-19 vaccine were 49% and 63%, respectively. Influenza vaccination was associated with working in public hospitals and all 5C constructs (more confidence, more collective responsibility and less complacency, constraints, and calculation), whereas stronger COVID-19 vaccination intention was associated with younger age, more confidence, less complacency and more collective responsibility. COVID-19-related demands were associated with greater work stress, and hence stronger COVID-19 vaccination intention.

Conclusion: The potential uptake rate of COVID-19 vaccine among nurses was suboptimal to achieve herd immunity. The 5C constructs were useful in predicting influenza vaccination and, to a lesser extent, the intention to take COVID-19 vaccine. The uncertain attributes such as effectiveness, side effects, and effective duration of the COVID-19 vaccine may contribute to this discrepancy. With less work stress among nurses in the post-pandemic period, the intention to take COVID-19 vaccine will likely drop. The 5C constructs should be infused in vaccination campaigns. While a COVID-19 vaccine could be ready soon, the nursing profession may not be ready to accept it. More research work is needed to boost the uptake rate.

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Tweetable abstract: Less than two-third of nurses intended to take COVID-19 vaccine when available. While a COVID-19 vaccine could be ready soon, nursing profession is not ready to accept it.

What is already known about the topic?

- The influenza vaccine uptake rate was slightly above 30% among nurses in Hong Kong in recent years.
- The psychological antecedents of vaccine hesitancy are predictive of the uptake of various existing vaccines.

What this paper adds

- COVID-19 might have boosted the influenza vaccine uptake rate to nearly 50%.
- The intention to take COVID-19 vaccine (63%), even when actualized, was insufficient to achieve herd immunity among nurses during a local outbreak.
- Vaccine hesitancy predicted actual vaccination against seasonal influenza and, to a lesser extent, COVID-19 vaccination intention.

1. Introduction

Vaccination is an effective approach to prevent infection and reduce mortality of many infectious diseases such as influenza (Osterholm et al., 2012) and human papillomavirus infection (Gallagher et al., 2018). However, vaccine hesitancy, a behaviour with delay in acceptance or refusal of vaccines despite available services, has depolarized the vaccine-supporters and their anti-vaccine counterparts. The World Health Organization (WHO) considered it as a global health threat in 2019. Three main factors are contributing to vaccine hesitancy: (i) individuals may lack confidence in and be fearful towards vaccines, especially with the misunderstanding that vaccines pose a risk of infection; (ii) individuals do not perceive a need for a vaccine (e.g. due to underestimation of disease severity) or do not value the vaccine; and (iii) individuals or community may have difficulties accessing the vaccine (World Health Organization, 2015). Vaccine hesitancy was most conspicuous in the influenza vaccine uptake in the general population. Ten years since the influenza pandemic in 2009, about half of the population in the United States did not have a seasonal influenza vaccine in 2019 (Centers for Disease Control and Prevention, 2019).

Healthcare workers in hospitals is a high-risk group during the epidemic. Healthcare workers' infection risk could be amplified during the ongoing epidemic due to various factors, including continuous exposure to patients, shortages of supply of personal protective equipment, and inadequate infection control training. During the 2003 severe acute respiratory syndrome (SARS) epidemic in Hong Kong, the first large transmission cluster occurred in Prince of Wales Hospital where healthcare workers accounted for a substantial proportion of infection with 43.6% among cases admitted to this hospital (Kwok et al., 2007; Lau et al., 2004). Healthcare workers were consequently accounted for about a quarter of total SARS infections in Hong Kong (Department of Health, 2005).

Before the 2003 epidemic of SARS-coronavirus (SARS-CoV), coronaviruses were considered as causing low health impact in humans and did not receive much attention. Five other human coronaviruses (OC43, 229E, NL63, HKU1, Middle East Respiratory Syndrome-CoV) have been circulating in humans for decades (Meyer et al., 2014). With their large genetic diversity and frequent genome recombination, an emerging coronavirus- SARS-CoV-2 was first identified in Wuhan, China in late December 2019, and resulted in subsequent Coronavirus COVID-19 infections in other Chinese provinces and ultimately all over the world. By 24 February 2020, 3,387 healthcare workers in medical facilities of 77,262 COVID-19 laboratory confirmed cases in China (4.4%) were recorded, of which 23 died from the infection (Zhan et al., 2020).

With the ease of control measures after the first epidemic wave, Europe experienced the COVID-19 resurgence in a few months (European Commission, 2020). Social distancing strategies were effective for mitigating COVID-19 (Kwok et al., 2020). However, this non-pharmaceutical intervention came at a high cost due to reduced economic activity (Thunström et al., 2020). With the continuous challenge of COVID-19, increasing the proportion of immune individuals among healthcare workers and the general population by vaccination as the indirect protection would be a viable option to avoid nosocomial infection. As of end of October, several COVID-19 candidate vaccines are in phase 3 trial with efficacy assessment in protecting human from SARS-CoV-2 infection (World Health Organization, 2020a). The WHO suggested the potential vaccines should have a minimum threshold of 50% efficacy at population level in reducing disease risk (World Health Organization, 2020c). However, the effect of vaccines on infection as well as the disease transmission were not fully evaluated. Although the vaccines concede protection from the disease, they might not reduce the transmission similarly. Even if effective vaccine is likely to be available soon, a substantial proportion may decline to be vaccinated. A survey conducted during the period of nationwide lockdown in France showed that a quarter of the adult population (26%) refused to be vaccinated against SARS-CoV-2 when available and were skeptical about its effectiveness (Coconel Group, 2020).

Understanding healthcare workers' vaccine hesitancy has substantial implications on public health administrations during epidemics. Healthcare workers' infections would reduce available healthcare workforce. Healthcare workers are usually at the front-line fighting with epidemics, and some of them are required to routinely perform procedures with high risks of contracting with pathogens. Protecting healthcare workers from infection plays a pivotal role in controlling nosocomial transmission. In addition, healthcare workers were a trustworthy and creditable source of vaccine-related information for patients (European Centre for Disease Prevention and Control, 2015). The WHO vaccine advisory group also highlighted healthcare workers' role in building public confidence in vaccines (World Health Organization, 2020b). Healthcare workers can convey the message of vaccination benefits and address the worries and concerns of the patients on a newly developed vaccine. However, prior research indicated that vaccine uptake rate among nurses was low, with influenza vaccine uptake rate slightly greater than 30% among nurses in Hong Kong (Kwok et al., 2019). In light of this, understanding determinants favoring vaccine uptake among nurses could have broader policy implications for improving COVID-19 vaccination programmes acceptability and dissemination (Dube, 2017).

Several theoretical models are available to examine the psychological underpinnings of vaccine hesitancy (Larson et al., 2014). By incorporating and expanding existing models, a framework of 5C psychological antecedents of vaccination including confidence (trust in vaccine effectiveness, safety, and necessity and the system

that delivers it), complacency (perceived the disease as low risk), constraints (perceived low vaccine availability, affordability, and accessibility), calculation (engagement in information searching), and collective responsibility (willingness to take the vaccine for protecting others via herd immunity) was recently developed (Betsch et al., 2018). This expanded framework has shown to explain a greater extent of variance in vaccination when compared with other models of vaccine hesitancy (Betsch et al., 2018).

On one hand, the 5C framework is generic, which aids our understanding of vaccination behaviors across different vaccines (e.g., influenza, HPV), settings (e.g., school, hospital), and populations (e.g., nurses, general public). On the other hand, the framework does not consider the specific environmental demands which may also contribute to vaccine hesitancy (e.g., Groenewold et al., 2012; Pless et al., 2017). During the early phase of the COVID-19 pandemic, nurses were stressed by multiple factors such as the lack of personal protective equipment (Ranney et al., 2020), deployment to isolation rooms (Maben and Bridges, 2020), and the attitudes toward the control measures of their organizations (Cheung, 2020). These factors may further explain nurses' intention to take COVID-19 vaccine.

In this study, we first estimated the proportion of nurses with the intention in receiving COVID-19 vaccine when available, and their influenza vaccine uptake rate. Second, a comparative analysis was conducted to examine how well the 5C psychological antecedents can predict both influenza vaccination and COVID-19 vaccination intention. Third, the association between work stress since the pandemic and COVID-19 vaccination intention, and the factors associated with the work stress were also investigated. In this regard, we examined whether work stress can mediate the effects of COVID-19-related work demand (i.e., insufficient supply of personal protective equipment, involvement in isolated rooms, and attitudes toward workplace infection control policies) on the intention to take COVID-19 vaccine.

2. Method

A cross-sectional online self-administered survey was conducted among nurses in Hong Kong. Participation was voluntary. The participants provided informed consent on the survey platform before they could proceed to the survey items. The items in the survey included demographics (year of birth, sex, rank, presence of chronic diseases), level of contacts with patients, influenza vaccine uptake and intention to take COVID-19 vaccine when available, statements measuring the 5C constructs, work stress level, supply of personal protective equipment, involvement in isolation rooms, and attitudes towards workplace infection control policies.

This study was approved by the Survey and Behaviour Research Ethics Committee of The Chinese University of Hong Kong (reference number: SBRE-19-251).

2.1. Participants

The required sample size to estimate seasonal influenza vaccine uptake rate and the proportion of those intend to be vaccinated against COVID-19 was 1,049 based on an estimated population of 60,000 registered or enrolled nurses in Hong Kong, a 3% margin of error, a 95% confidence interval, and a prevalence rate at 50%. To account for a 30% loss from invalid cases (ineligible or incomplete cases), the sample size required was 1,499. The online survey was disabled when the sample size was achieved.

In collaboration with the Association of Hong Kong Nursing Staff, their members (including registered nurses, enrolled nurses, and nursing trainees in public or private medical facilities) were recruited in this study from 16 March to 29 April 2020. Among over 50,000 registered or enrolled nurses in Hong Kong, over 60% were members of the Association of Hong Kong Nursing Staff. A sample recruited via this association would be rather representative of the nurses in Hong Kong. Participants were compensated with a coupon of HKD 25. Nursing trainees and retired nurses were excluded from this analysis.

2.2. Measures

Vaccine hesitancy was measured using a 15-item tool developed from a "5C model" of psychological antecedents to vaccination (Betsch et al., 2018). Each of the 5 antecedents including confidence, complacency, constraints, calculation, and collective responsibility, was assessed by 3 rating items on a 7-point scale (1=*strongly disagree*; 7=*strongly agree*). Mean scores of items under each domain were computed, with higher average score indicating stronger agreement of the corresponding domain.

Work stress was measured by a single item asking participants to self-rate their level of work stress since the outbreak of COVID-19 on an 11-point scale (0=*no stress at all*; 10=*the maximum stress*). Insufficient supply of personal protective equipment was measured by asking participants to report any shortage of 7 personal protective equipment and an open option (1=*yes*; 0=*no*). The higher the total score, the more insufficient supply of personal protective equipment was. A single item asking participants whether their job duties included work in infection isolation rooms (1=*yes*; 0=*no*). Attitudes towards workplace infection control policies were measured by 3 items stating if the workplace infection control policies were timely, sufficient, and effective, respectively, on a 5-point rating scale (1=*strongly disagree*; 5=*strongly agree*).

Seasonal influenza vaccine uptake was measured by self-reported vaccination in 2019/20 while COVID-vaccine uptake intention was measured by a single item asking participants how likely they will take the COVID-19 vaccine when available on a 11-point Likert scale (0=*definitely no*; 10=*definitely yes*).

2.3. Statistical analysis

To examine the potential bias on excluded cases, the sample characteristics were compared between those excluded and analyzed responses. To further examine the sample representativeness, several sample characteristics were compared with those reported in two large-scale Health Manpower Surveys conducted by the Department of Health of the Hong Kong SAR government. We summarized the characteristics of the study participants with descriptive statistics such as mean, frequency, percentage and 95% binomial confidence interval (bCI) and their bivariate correlations. A factor analysis using principal axis factoring approach was conducted to examine the factorial validity of the 5C model in the current population. Multiple linear regression and logistic regression models were applied to identify factors associated with COVID-19 vaccine uptake intention and actual influenza vaccine uptake, respectively, controlling for demographic, health and environmental factors. The mediating effect was tested using path analysis with 2,000 bootstrapped samples. A statistical significance was based on p-value of 0.05. All analyses were conducted in R (v3.6.3) and Stata 16.0.

3. Results

Totally, 1,660 attempts to complete the survey were recorded, of which 1,205 respondents were retained for the analyses. Excluded cases were those who had retired (n=37), are full-time nursing students (n=95), or provided incomplete responses (n=323). No statistically significant difference was found in sex composition, presence of chronic diseases, being a member of the Association of

Table 1
Comparison among Analyzed Cases, Excluded Cases, and Cases from Population Surveys.

		Analyzed	Excluded		Health Manpower Surveys	
		Frequency/ mean	Frequency/ mean	Compared with analyzed sample	Frequency/ mean	Compared with analyzed sample
Binary predictor		*n* (%)	*n* (%)		*n* (%)	
Women	– Yes	1081 (89.7)	329 (90.1)	χ^2 (1) = 0.06, p = .81	13567 (87.4)	χ^2 (1) = 5.33, p = .02
	– No	124 (10.3)	36 (9.9)		1950 (12.6)	
Degree holder	– Yes	394 (32.7)	119 (26.2)	χ^2 (1) = 6.62, p = .01	3751 (24.1)	χ^2 (1) = 44.22, p < .001
	– No	811 (67.3)	336 (73.9)		11802 (75.9)	
Hospital Authority	– Yes	693 (57.4)	162 (50.3)	χ^2 (1) = 5.22, p = .02	9540 (61.3)	χ^2 (1) = 6.89, p = .009
	– No	512 (42.6)	160 (49.7)		6013 (38.7)	
Chronic diseases	– Yes	153 (12.7)	39 (10.7)	χ^2 (1) = 1.06, p = .30		
	– No	1052 (87.3)	326 (89.3)			
AHKNS member	– Yes	1154 (95.8)	355 (97.3)	χ^2 (1) = 1.67, p = .20		
	– No	51 (4.23)	10 (2.74)			
Influenza vaccination	– Yes	597 (49.5)	152 (50.3)	χ^2 (1) = 0.06, p = .81		
	– No	608 (50.5	150 (49.7)			
Continuous predictor		*Mean* (*SD*)	*Mean* (*SD*)		*Mean*	
Age		40.79 (10.47)	38.35 (12.53)	t (1568) = −3.72, p < .001	41.56	t (1569) = −2.54, p = .01
Sample size		1205	365		15553	
Patient contact frequency		4.23 (1.24)	3.93 (1.46)	t (1525) = −3.74, p < .001		
Sample size		1205	322			
COVID-19 vaccine intention		6.52 (2.83)	7.44 (2.40)	t (1274) = 2.67, p = .008		
Sample size		1205	71			

Table 2
Sample characteristics, crude odds ratios predicting influenza vaccination, and correlations with COVID-19 vaccine intention (N = 1205).

			Influenza vaccination	COVID-19 vaccination intention
Predictor (range)	Mean / %	SD	OR (95%CI)	*r*
Age (21-71)	40.79	10.47	**1.01 (1.00, 1.02)**	−0.03
Sex (1 = women)	89.71%		0.98 (0.68, 1.42)	−0.02
Chronic diseases (1 = yes)	12.70%		**1.54 (1.09, 2.17)**	0.00
Public hospitals (1 = yes)	56.35%		1.25 (1.00, 1.57)	−0.03
Patient contact frequency (1-5)	4.23	1.24	0.98 (0.89, 1.07)	0.01
Confidence (1-7)	4.94	1.21	**3.25 (2.81, 3.77)**	0.38***
Complacency (1-7)	3.64	1.24	**0.56 (0.51, 0.62)**	−0.20***
Constraints (1-7)	3.15	1.28	**0.69 (0.63, 0.76)**	−0.06*
Calculation (1-7)	5.61	0.88	1.03 (0.90, 1.17)	0.11***
Collective responsibility (1-7)	5.28	1.16	**2.43 (2.13, 2.78)**	0.33***
Work stress (0-10)	7.38	2.06	**1.06 (1.00, 1.12)**	0.21***
Insufficient supply of PPE (0-8)	2.79	1.87	0.96 (0.91, 1.02)	0.04
Involvement in isolated rooms (1 = yes)	32.70%		0.98 (0.77, 1.25)	−0.03
Attitudes toward control policies (1-5)	2.56	1.05	1.14 (1.02, 1.27)	−0.03

* p < .05.
*** p < .001.PPE: personal protective equipment.Significant odds ratios (95% confidence interval) are presented in bold face.

Hong Kong Nursing Staff, and ever had influenza vaccination between those with complete and incomplete responses. Those with complete responses, however, were more likely to be degree holders, working in the public service run by Hospital Authority, older, have more frequent contact with patients, and a weaker intention to take COVID-19 vaccine than those with incomplete responses. Registered nurses (80%) were slightly overrepresented in our sample as compared with the percentage of registered nurses in the Nursing Council of Hong Kong (75%), $\chi^2(1)$=8.62, p=.003. Nurses in this sample were slightly more likely to be women, degree holders, less likely to work in Hospital Authority, and younger as compared with those in the Health Manpower Survey (Table 1).

Table 2 shows sample characteristics and their bivariate associations with influenza vaccine uptake and COVID-19 vaccine intention, respectively. The mean age of the sample was 40.79 years (*SD*=10.47). Most participants were female (90%) and Association of Hong Kong Nursing Staff members (96%). More than half of the participants worked in the public hospitals (56%). Participants reported high exposure to patients (*M*=4.35 on a scale of 1-5; *SD*=1.23).

The influenza vaccine uptake rate in the 2019-2020 winter season was 49% (95% bCI: 47%, 52%). Univariate determinants associated with higher influenza vaccine uptake were older age, presence of chronic diseases, stronger vaccine confidence, collective responsibility, and work stress; and weaker vaccine complacency and constraints. Intention to take COVID-19 vaccine when available was 6.52 (on a scale of 0-10; *SD*=2.83), which could be translated to 63% (95% bCI: 60%, 66%) reporting they were likely to vaccinate (scored 6 or above). Univariate factors associated with stronger intention to take COVID-19 vaccine were stronger vaccine confidence, calculation, collective responsibility, and work stress; and weaker complacency and constraints. Correlations among the studied variables and Cronbach's alpha coefficients for composite measures are presented in Table S1.

The results of a parallel analysis showed that 5 factors should be retained for the vaccine hesitancy measure. The results of Bartlett's test, $\chi^2(105)$=7841.71, p<.001, and KMO measure (.82) also supported the factorability and sufficiency of the data. Using Oblimin rotation, all items conformed to the original factor structure, with factor loadings ranging from .63 to .84, except the only reverse item tapping collective responsibility (Table S2). It was removed and subsequently increased the Cronbach's alpha coefficient of collective responsibility from .62 to .82.

To explore the relationship between the progression of number of daily confirmed cases and nurses' intention to take COVID-19 vaccine, we overlaid the averaged intention of each reporting day

Table 3
Effects of the 5C model of vaccine hesitancy on influenza vaccination and COVID-19 vaccination intention.

	Influenza vaccine		COVID-19 vaccination intention	
	Covariates only	Full model	Covariates only	Full model
	aOR (95%CI)	aOR (95%CI)	β (95%CI)	β (95%CI)
Intercept	0.71 (0.34, 1.51)	**0.06 (0.01, 0.29)**		
Age (21–71)	1.01 (1.00, 1.02)	0.99 (0.98, 1.01)	−0.03 (−0.09, .03)	−0.07 (−0.12, −0.01)*
Sex (1 = women)	1.00 (0.69, 1,46)	0.91 (0.57, 1.47)	−0.03 (−0.08, .03)	−0.03 (−0.08, .03)
Chronic diseases (1 = yes)	1.43 (1.00, 2.05)	1.01 (0.64, 1.60)	.01 (−0.05, .07)	−0.03 (−0.08, .03)
Public hospitals (1 = yes)	1.27 (1.00, 1.61)	**1.56 (1.16, 2.10)**	−0.03 (−0.09, .03)	−0.02 (−0.08, .03)
Patient contact frequency (1–5)	0.97 (0.88, 1.06)	0.98 (0.87, 1.11)	.01 (−0.05, .07)	.02 (−0.03, .07)
Confidence (1–7)		**2.70 (2.27, 3.22)**		.29 (.22, .35)***
Complacency (1–7)		**0.69 (0.60, 0.79)**		−0.11 (−0.17, −0.05)***
Constraints (1–7)		**0.83 (0.73, 0.94)**		.03 (−0.02, .09)
Calculation (1–7)		**0.62 (0.51, 0.75)**		.05 (.00, .11)
Collective responsibility (1−7)		**1.67 (1.40, 1.98)**		.12 (.06, .19)***
Pseudo R^2	0.71	29.91		
R^2			0.27	17.70

* $p < .05$.
*** $p < .001$.Significant odds ratios (95% confidence interval) are presented in bold face.

over the epidemic curve of Hong Kong (Figure S1). The data collection period covered the wave of COVID-19 outbreak in March and April 2020 in Hong Kong. The data reflected that intention was high and stable during the burst of imported cases and local transmissions. A sudden drop in the intention to take COVID-19 vaccine was observed when the number of confirmed cases dropped at the end of this wave of the outbreak. The level of intention was reinstated and less stable afterward.

3.1. Factors associated with influenza vaccine uptake and intention to take COVID-19 vaccine

The reference models predicting influenza vaccine uptake or COVID-19 vaccination intention included only covariates. Adding 5C into the influenza vaccination model increased the pseudo R^2 from 0.71% to 29.91%. In the final logistic regression model, influenza vaccination was associated with working in public hospitals, *aOR*=1.56 (95%CI=1.16, 2.10), and having stronger vaccine confidence, *aOR*=2.70 (2.27, 3.22), and collective responsibility, *aOR*=1.67 (1.40, 1.98), and weaker complacency, *aOR*=0.69 (0.60, 0.79), constraints, *aOR*=0.83 (0.73, 0.94), and calculation, *aOR*=0.62 (0.51, 0.75). In comparison, adding 5C into COVID-19 vaccination model increased the R^2 from 0.27% to 17.70%. In the final multiple regression model, intention to take COVID-19 vaccine was associated with being younger, β=-.07, p=.02, and having stronger vaccine confidence, β=.29, p<.001, and collective responsibility, β=.12, p<.001, and weaker complacency, β=-.11, p<.001. Table 3 shows the coefficients of the two regression models. When COVID-19 vaccination intention was dichotomized as likely (score 6-10) and not likely (score 0-5), the pseudo R^2 of the model was 10.19%. The coefficients of the dichotomized COVID-19 vaccination intention model are presented in Table S3.

3.2. Effects of COVID-19 demands on vaccination intention via work stress

To assess whether work stress mediated the association between COVID-19-related demands and vaccination intention, we conducted a path analysis with 2,000 bootstrapped samples (Fig. 1, Table 4). The indirect effects of insufficient supply of PPE, β=.04, p<.001, involvement in isolation rooms, β=.09, p=.005, and attitudes towards control policies of public authorities, β=-.07, p=.001, on COVID-19 vaccination intention via work stress were significant. Insufficient supply of PPE, β=.17, p<.001, involvement in isolated rooms, β=.39, p=.001, and unfavorable attitudes towards control policies of public authorities, β=-.29, p<.001, were associated with work stress. Work stress was subsequently associated with vaccination intention, β=.22, p<.001, controlling for the predictors in the previous COVID-19 vaccination intention model and the influenza vaccination status.

4. Discussion

This large-scale cross-sectional online survey during the early phase of COVID-19 outbreak was the first study presenting the uptake behaviour/intention of both influenza and potential COVID-19 vaccine among nurses. We reported the estimates of both influenza vaccine uptake and intention to have COVID-19 vaccine, and identified their associated factors.

Despite the uncertainty of vaccine attributes such as effectiveness, side effects and duration of protection, 63% of the respondents indicated that they were likely to opt for COVID-19 vaccine when it becomes available. In the past few months, there was a surge of interest in estimating the intention to be vaccinated against COVID-19 around the world (e.g., Detoc et al., 2020; Graffigna et al., 2020; Reiter et al., 2020; Sherman et al., 2020; Wong et al., 2020). A recent survey of almost 20,000 adults in 27 countries conducted in July and August 2020 showed that 74% of adults intended to receive COVID-19 vaccine when available, with the highest rates in China (97%), Brazil (88%), Australia (88%), and India (87%) and the lowest in Russia (54%), Poland (56%), Hungary (56%), and France (59%) (Dai, 2020). Our findings were unique in revealing the intention to be vaccinated against COVID-19 in the population of nurses and its relatively lower rate compared with the world average. In recent years, nurses were slightly more likely to take the influenza vaccine than the general population in Hong Kong (Kwok et al., 2019; Sun et al., 2020). Thus, the difference in COVID-19 vaccination intention from the world average may be attributed to the geographical differences rather than our special sub-population. We speculated that the relatively low vaccination intention may in part be explained by the successful crisis response on the COVID-19 epidemic in Hong Kong (Hartley and Jarvis, 2020) and the distrust in health authorities (e.g., Hartley and Jarvis, 2020; Siu, 2012). Empirical data are needed to substantiate these propositions.

Younger age, stronger confidence and collective responsibility, and weaker complacency were associated with stronger intention to be vaccinated against COVID-19. The generic psychological antecedents of vaccination were applicable to predict the inten-

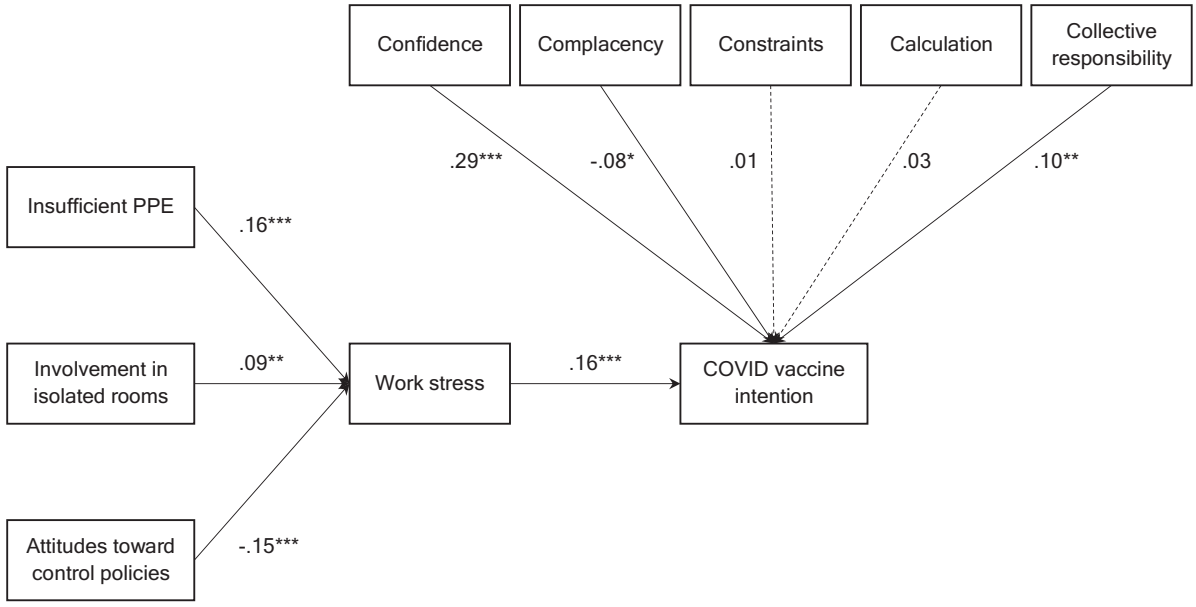

Fig. 1. The effects of 5C and the mediation effect of work stress on COVID-19 vaccination intention.

Table 4
Direct and indirect effects of situational factors on COVID−19 vaccination intention.

	Work stress β (95%CI)	COVID−19 vaccination intention β (95%CI)
Direct effects		
Age	.01 (−0.06, .08)	−0.03 (−0.09, .04)
Sex	−0.01 (−0.06, .05)	−0.02 (−0.07, .03)
Chronic diseases	.03 (−0.03, .09)	−0.03 (−0.09, .03)
Public hospitals	.04 (−0.02, .09)	−0.03 (−0.09, .02)
Patient contact frequency	.03 (−0.03, .10)	.02 (−0.04, .07)
Lack of PPE	.16 (.09, .22)***	.07 (.01, .13)
Involvement in isolated rooms	.09 (.04, .14)**	−0.04 (−0.09, .02)
Attitudes toward control policies	−0.15 (−0.22, −0.08)***	−0.07 (−0.13, .00)
Influenza Vaccination (1= yes)		.04 (−0.03, .10)
Confidence		.29 (.21, .37)***
Complacency		−0.08 (−0.14, −0.02)*
Constraints		.01 (−0.05, .07)
Calculation		.03 (−0.02, .09)
Collective responsibility		.10 (.03, .18)**
Work stress		.16 (.10, .22)***
R^2	8.51%	21.20%
Indirect effects via work stress		
Age		.00 (−0.01, .01)
Sex		.00 (−0.01, .01)
Chronic diseases		.00 (.00, .01)
Public hospitals		.01 (.00, .02)
Patient contact frequency		.01 (−0.01, .02)
Lack of PPE		.03 (.01, .04)***
Involvement in isolated rooms		.01 (.00, .02)**
Attitudes toward control policies		−0.02 (−0.04, −0.01)**

* $p < .05$.
** $p < .01$.
*** $p < .001$.

tion to receive COVID-19 vaccine as shown in studies of other vaccines (Betsch et al., 2018; Neufeind et al., 2020). The findings can inform the design of future vaccination campaigns. Also, the specific COVID-19-related demands including insufficient supply of personal protective equipment, involvement in isolated rooms, and unfavorable attitudes towards workplace infection control policies among nurses in the early phase of the epidemic in Hong Kong were associated with greater work stress which in turn resulted in stronger intention to have COVID-19 vaccine. Similar to a risk perception survey among the general population of Hong Kong (Kwok et al., 2020a), the experience of SARS contributing to strong psychological responses, as reflected in nurses' pressure level, underlined their intention to be vaccinated against COVID-19. This may also apply to influenza vaccination. About half of the respondents (49%) reported to receive influenza vaccine in the 2019/2020 season. This estimate is statistically higher than those observed in similar surveys from the same population in 2013/2014, 2014/2015, 2015/2016, 2016/2017 seasons (32%, 28%, 33% and 36% respectively) (Chan et al., 2015; (Kwok et al., 2019); Li et al., 2019). This high rate may possibly be due to the similarity

of COVID-19 symptoms with those observed in influenza or other respiratory diseases (Kwok et al., 2020b). Working in the public hospital, more confidence, less complacency, less constraints, less calculation and more collective responsibility were associated with the decision to take the influenza vaccine. The 5C model was more predictive of influenza vaccine uptake than intention to take COVID-19 vaccine based on the pseudo R^2 coefficients of the models, which might be attributed to the unknown and uncertainties of the new human coronavirus.

Our study has several important public health implications. First, identification of determinants associated with COVID-19 vaccination intention and influenza vaccination helps inform future vaccination campaigns. Older nurses with less intention to have COVID-19 vaccine may contribute to possible nosocomial infection by their close contact with COVID-19 patients in the hospital. As older individuals are more susceptible to COVID-19 than younger individuals (Niu et al., 2020), infection risk of older nurses will be higher in the future waves of COVID-19 epidemic. Older and experienced medical staff are particularly valuable in public health emergency. The protection to this high-risk and highly valuable subgroup is particularly important during an outbreak. With sporadic cases or fewer imported cases after the major epidemic globally and further improvement in infection control practices, work-related stress of nurses will likely to be lower comparing with the early pandemic. Nurses' intention to take COVID-19 vaccine may consequently lessen when the vaccine becomes available. Another challenge is that age is a mortality risk factor for COVID-19 infection with no exception to medical staff. Among the 278 physicians who died with COVID-19 infection till April 2020, their median age was 66 years (Ing et al., 2020). Despite the mortality risks, older nurses are less likely than younger nurses to take the vaccine against COVID-19. With their experience, they are likely to be the role models of the junior nurses (To et al., 2015). Health authorities may tailor a vaccination program to nurses, in particular older nurses, to have COVID-19 vaccination. Future research is also needed in order to investigate why older nurses have a higher vaccination hesitancy, and explore potential strategies in consciousness raising and attitude changing towards vaccination.

Second, uptake of the safe and effective vaccine could only be considered as an additional measure to help control the COVID-19 pandemic. Assuming the population of COVID-19 vaccine uptake rate is similar to that observed among nurses in this study (63%, which is lower than the world average of 74%; (Dai, 2020)) with a WHO recommended efficacy of 50% of successful vaccine, the spread of infection will be halted if the effective reproductive number Rt, a measure to estimate the number of secondary cases generated by an index case in the presence of interventions, is below 1.45. Apart from vaccination campaigns to boost uptake rate and continuous development of antiviral therapy, the health authority should further consider to conduct modelling studies to explore the optimal levels of assorted interventions including encouragement of social-distancing adoption, border controls, active case surveillance and contact tracing to maintain the epidemic in a manageable level (Panovska-Griffiths, 2020).

Third, more emphasis should be placed on psychological components when implementing the nation-wide vaccination program. Our statistical framework suggested that the variation of psychological constructs in the 5C model contributed a significant proportion to explain both influenza vaccine uptake and COVID-19 vaccination intention. Our findings were consistent with a previous study that the 5C scale could well examine the psychological antecedents of influenza vaccination (Betsch et al., 2018). However, the power of 5C was weaker in predicting COVID-19 vaccination intention. It is not surprising that calculation and constraints in the 5C model were found to be not associated with this intention. Given very limited information related to COVID-19 vaccine during the early phase of the epidemic, respondents were not able to perform an extensive information search and evaluate their synonyms for the possible perceived barriers on the new vaccine. The validity of the 5C model may increase as there is more information about the new vaccine. Further validation work of vaccine hesitancy models on COVID-19 vaccine is warranted. When the strongest interventions such as mandatory vaccination or opt-out policies (Lytras et al., 2016) are not ethically justified, targeting the 5C components through evidence-informed interventions (Dube, 2017), health communication approaches (Goldstein et al., 2015), and new media (Pedersen et al., 2020) may be some viable options.

Fourth, our findings also have global implications. By early May 2020, more than 150,000 healthcare workers had been infected with COVID-19 and more than 1,400 had died worldwide (Bandyopadhyay et al., 2020). The safety of healthcare workers, as the most valuable resource for every country in the COVID-19 pandemic, must be ensured (The Lancet, 2020). While the expecting COVID-19 vaccine could be effective in protecting the healthcare workers, our data shows vaccine hesitancy is likely a hurdle for the uptake. Vaccine hesitancy, as a global threat, is affecting all countries. For instance, a study has shown the French population in 2016 had recorded the highest vaccine hesitancy, which was associated with lower vaccine uptake and benefit-to-risk balance (Rey et al., 2018). The lesson learnt among nurses in Hong Kong would be helpful for the development of vaccine campaigns in the rest of the world, especially for healthcare workers, to prevent or prepare for the next wave of outbreak or future pandemics.

This study has a couple of limitations. First, a convenience sampling approach may result in potentially biased estimates. Second, this was a cross-sectional study which could not infer the causal relationship. Third, possible recall bias may occur in self-reporting measurements. Fourth, not all components in the 5C vaccine hesitancy model could address the intention to have COVID-19 vaccine hesitancy when the vaccine attributes are not available. Fifth, while this study showed the validity of the 5C model in predicting COVID-19 vaccination intention, it failed to identify additional factors that may be unique to this particular virus and population. A qualitative study may be able to broaden our understanding and inform promotion campaigns and interventions. Sixth, the intention to receive COVID-19 vaccine may be sensitive to the time-varying infection and mortality rate of the ongoing pandemic.

5. Conclusion

This study provided additional validity evidence for the 5C model of psychological antecedents of vaccination and showed its potential in predicting and promoting COVID-19 vaccine when available. While we are cautiously optimistic that the vaccine will decrease the transmission, its ability to control the pandemic is dependent on multiple factors such as uptake rate and vaccine effectiveness. If only 63% of nurses during an outbreak in Hong Kong intended to take the COVID-19 vaccine with 50% efficacy, we anticipate that promoting the vaccine to the general public in the post-pandemic period will be more challenging. While a vaccine could be ready very soon, our nursing profession and probably many alike are not ready to accept it. More research work is needed to optimize the uptake of the vaccine, our best hope so far.

Conflict of interest

None.

CRediT authorship contribution statement

Kin On Kwok: Conceptualization, Methodology, Formal analysis, Writing - original draft. **Kin-Kit Li:** Conceptualization, Methodology, Formal analysis, Writing - original draft. **Wan In WEI:** Data curation, Writing - review & editing, Project administration. **Arthur Tang:** Conceptualization, Writing - review & editing. **Samuel Yeung Shan Wong:** Resources, Writing - review & editing, Supervision. **Shui Shan Lee:** Resources, Writing - review & editing, Supervision, Funding acquisition.

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Supplementary materials

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