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Levels and factors derived from the Health Action Process Approach of behavioral intentions to take up COVID-19 vaccination: A random population-based study



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ABSTRACT

Objectives: COVID-19 vaccination needs a high population coverage to achieve herd immunity. We investigated prevalence of three scenarios of intention of free COVID-19 vaccination involving: 1) 80% effectiveness and rare and mild side effects (Scenario 1), 2) 50% effectiveness and rare and mild side effect RMSE (Scenario 2), and 3) immediate vaccination (Scenario 3), and their associated factors derived from the pre-intentional motivational phase of the Health Action Process Approach (HAPA).

Methods: A random population-based telephone survey interviewed 450 Chinese adults in the general population (September 16–30, 2020). The four HAPA constructs included a) risk perception scale, b) overall scale/four subscales of positive outcome expectancy of COVID-19 vaccination, c) overall scale/three subscales of negative outcome expectancy of COVID-19 vaccination, and d) the overall scale/two subscales of self-efficacy of COVID-19 vaccination.

Results: The prevalence of intention of COVID-19 vaccination under Scenarios 1 to 3 was 38.0%, 11.1%, and 13.1%, respectively. Logistic regression analyses adjusted for background factors showed that 1) the associations between risk perception and the three scenarios of intention were non-significant; 2) the overall scale/four subscales of positive outcome expectancy were in general positively associated with two scenarios of intention (80% effectiveness and immediate vaccination); 3) the overall scale/three subscales of negative outcome expectancy were in general negatively associated with all three scenarios of intention; 4) the overall scale/two subscales of self-efficacy were only positively associated with the intention that involved 80% effectiveness. When all the four overall scales were entered into an adjusted model, positive and negative outcome expectancy, but not risk perception and self-efficacy, were independently associated with the three scenarios.

Conclusions: In this study population, the prevalence of intention of COVID-19 vaccination was very low and might not result in population protection. Health promotion should modify outcome expectancies to increase intention of COVID-19 vaccination.

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1. Introduction

Globally, the Coronavirus Disease 2019 (COVID-19) pandemic has accumulated over 265 million cases and over five million deaths as of December 2nd, 2021 [1]. COVID-19 vaccination is probably the most promising means to control the pandemic. Scientists claimed that high population coverage rates of COVID-19 vaccination exceeding 70% to 80% are required to control the pan-

demic [2]. Vaccine hesitancy, however, remains a global issue. COVID-19 vaccines were firstly rolled out in late December 2020 in a number of countries [3]. Many vaccination intention studies were conducted prior to the approval of any COVID-19 vaccines and their rollouts. It is a limitation that many of such studies were based on convenient sampling methods, which were not population-based. Reviews of such studies reported high levels of vaccine hesitancy against COVID-19 vaccination in many countries [4,5]. Since COVID-19 vaccines were then unavailable, such studies could only ask about vaccination acceptance/intention but not actual vaccination behavior. Vaccination intention research was meaningful, as intention is a known good predictor of actual

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behaviors [6]. Understanding the associated factors of COVID-19 vaccination intention during pre-rollout periods would facilitate designing early interventions to promote vaccination behaviors.

Socio-demographics such as sex, age, educational level, marital status, having children under 18, employment status, and chronic disease status, were all associated with behavioral intention of COVID-19 vaccination [7,8] and determinants of vaccination intention [9,10]. For instance, females were more likely than males to perceive negative outcome expectancy of COVID-19 vaccination (e.g., side effects) [11]. Such potential confounders were hence adjusted for in data analyses of the present study. COVID-19-related perceptions (e.g., perceived efficacy of COVID-19 vaccines and perceived severity of the COVID-19 pandemic) were also significant factors of COVID-19 vaccination intention [12–16].

The present study looked at factors of vaccination intention during the pre-rollout period. It was theory-based. A review found that interventions based on behavioral health theories were more effective than non-theory-based interventions [17]. The commonly used Theory of Planned Behavior (TPB) postulates that attitudes, subjective norm, and perceived behavioral control would affect behavioral intention, which would in turn determine the actual behavior [18]. The pre-intentional motivational phase of the Health Action Process Approach (HAPA) also focuses on behavioral intention [19]. It postulates that behavioral intention is determined by: 1) risk perception (i.e., individuals' perceived susceptibility to a health threat), 2) positive outcome expectancy regarding the particular behavior, 3) negative outcome expectancy of the particular behavior, and 4) self-efficacy (i.e., confidence in performing the behavior). The post-intentional volitional phase of HAPA includes constructs that link up behavioral intention and action, including 1) action planning (i.e., detailed instructions of performing the behavior) and coping planning (i.e., performing the behavior when obstacles occur), and 2) maintenance and recovery self-efficacy (i.e., confidence in maintaining the behavior and resuming the behavior after a relapse). However, this phase could not be used in this pre-rollout study as no vaccination then took place. The approach of using the pre-intentional phase of HAPA is appropriate, as a large number of studies have only focused on the pre-intentional motivational phase of the HAPA, including studies on condom use, physical activities, and smoking [20–22]. It has also been used to understand behavioral intentions of influenza vaccination [23] and HPV vaccination [24].

The pre-intentional motivational phase of the HAPA, instead of the TPB, was used in this study as the theoretical framework, as three of the HAPA constructs (risk perception and positive and negative outcome expectancies) have particular relevance to the pandemic and COVID-19 vaccination. First, as COVID-19 has caused millions of infections, many people may perceive high risk of infection, which was associated with COVID-19 vaccination intention [25] and behavior [26]. Second, COVID-19 vaccination leads to positive outcomes at individual (e.g., protection, restoration of normal life, and alleviation of mental distress) and community levels (e.g., controlling the pandemic at the city/country level) and negative outcomes (e.g., severe side effects). In literature, attributes related to both perceived positive and negative outcomes were consistently associated with vaccination intention [8,11]. Third, self-efficacy, which was similar to the construct of perceived behavioral control of the TPB, was associated with vaccination behaviors (e.g., influenza and HPV vaccination) [24,27].

The present study investigated factors of three scenarios of behavioral intention of free COVID-19 vaccination in the general adult population in Hong Kong: 1) intention to take up free vaccination with an effectiveness of 80% and rare and mild side effects, 2) intention to take up free vaccination with an effectiveness of 50% and rare and mild side effects, 3) immediate intention (taking up free COVID-19 vaccination at the soonest upon its availability).

Immediate intention was assessed as the timing of COVID-19 vaccination is crucial in determining the population coverage rate, while previous studies showed that many people were holding a 'wait-and-see' attitude [7]. As mentioned, the four potential factors of these three scenarios were derived from the pre-intentional motivational phase of the HAPA. It was hypothesized that the HAPA constructs of positive outcome expectancy, risk perception, and self-efficacy would be positively associated with the three vaccination intention scenarios, while negative outcome expectancy would be negatively associated with such vaccination intention scenarios.

2. Methods

2.1. Study design

An anonymous population-based telephone survey (n = 450) of 15–20 min was conducted among Chinese speaking Hong Kong residents (aged ≥ 18) during September 16–30, 2020, and between 6 and 10:30 pm to avoid over-sampling non-working individuals. Telephone numbers were randomly drawn from the most updated residential telephone directory. Unanswered telephone calls were given at least three attempts. The eligible household member whose birthday was closest to the survey date was interviewed. Appointments were made if necessary. Experienced interviewers briefed the participants about the study and sought verbal informed consent and signed a form pledging having completed the required procedures. No incentives were given to the participants. Participants could quit at any time. The response rate, defined as the number of participants divided by (the number of completed interviews + the number of refusals) was 51.4%. The telephone survey design has been used in many published studies [28,29]. Ethics approval was obtained from the corresponding author's affiliated institution.

2.2. Measures

Background factors included socio-demographics (sex, age, educational level, marital status, having children under 18, and employment status) and chronic disease status (e.g., diabetes and hypertension).

Behavioral intention of COVID-19 vaccination: There were three scenarios of vaccination intention. The first two asked about the behavioral intention of taking up free COVID-19 vaccination (i.e., without monetary cost) that incurred only rare and mild side effects within the first six months since its availability under two scenarios [a] S1: an effectiveness of 80% (i.e., protection against COVID-19 infection) and b) S2: an effectiveness of 50% (1 = definitely not to 5 = definitely yes). In logistic regression analysis, these two scenarios were recoded into two binary variables (probably/definitely yes versus else). The third scenario asked about the intention to take up COVID-19 vaccination as soon as it became available (S3: immediate vaccination) (yes/no). It implies people considering COVID-19 vaccination without considering the issues of effectiveness and safety.

Risk perception: One item assessed the participant's self-perceived likelihood of contracting COVID-19 in the future 12 months (1 = extremely low to 5 = extremely high). The item was used in other published papers [30,31].

Positive outcome expectancy: The perceived likelihoods of experiencing four dimensions of positive outcomes of COVID-19 vaccination were assessed (1 = extremely low to 5 = extremely high). The four subscales and their items were: 1) **protection effect** [2-item subscale (Cronbach's alpha = 0.92): "Taking up COVID-19 vaccination could protect me from contracting COVID-

19” and “Taking up COVID-19 vaccination could protect my family members/friends from contracting COVID-19 via me”), 2) **restoration of normal life** [2-item subscale (Cronbach’s alpha = 0.75): “COVID-19 vaccination relieves me from always wearing face-masks to prevent COVID-19” and “COVID-19 vaccination allows me to resume my normal social life”), 3) **psychological relief** (one item subscale: “COVID-19 vaccination could make me more relieved from the fear of contracting COVID-19”), and 4) **contribution to Hong Kong**: (one item subscale: “COVID-19 vaccination allows me to contribute to the control of the COVID-19 pandemic in Hong Kong”). The score of the overall positive outcome expectancy scale was calculated by summing up all the above six items (Cronbach’s alpha = 0.86).

Negative outcome expectancy was assessed by the perceived likelihood of experiencing three subscales of negative outcomes of COVID-19 vaccination (1 = extremely low to 5 = extremely high). The three single-item subscales were: 1) **causing infection**: “COVID-19 vaccination could result in COVID-19 infection”, 2) **severe side effects**: “COVID-19 vaccines may have severe side effects”, and 3) **limited protectiveness**: “Even having taken up COVID-19 vaccination, it is still possible to contract COVID-19 due to the vaccines’ limited protectiveness”. The score of the overall negative outcome expectancy scale was calculated by summing up all the above three items (Cronbach’s alpha = 0.86).

Self-efficacy: Two single-item subscales assessed perceived self-efficacy of taking up COVID-19 vaccination (1 = totally disagree to 5 = totally agree): 1) “You are confident in taking up COVID-19 vaccination if you want to”, and 2) “It is easy for you to take up COVID-19 vaccination if you want to”. The score of the overall self-efficacy scale was calculated by summing up all the above two items (Cronbach’s alpha = 0.95).

2.3. Data analysis

Chi-square test was conducted to compare the background factors (i.e., sex, age, educational level, marital status, whether having children under 18, employment status, and chronic disease status) between those having and not having each of the three scenarios of behavioral intention. To facilitate comparisons and interpretations, both the overall scales and the subscales of the four HAPA constructs were all rescaled to the same range (1–5). Adjusted for the background variables, the individual associations between the four overall scale scores of the HAPA and the three binary vaccination intention scenarios were analyzed by using multiple logistic regression analysis. A similar second round of adjusted analysis examined the individual associations between the subscales of the HAPA and the three types of behavioral intention. Finally, a summary model was derived by entering the four overall scales of the HAPA constructs simultaneously into the three logistic models of the three scenarios of behavioral intention, after adjusted for the background variables. Odds ratio (OR) and respective 95% confidence intervals (CIs) were derived from these logistic regression models. SPSS 21.0 was used for data analysis. Statistical significance was defined as $p < .05$ (two-tailed).

3. Results

3.1. Descriptive statistics

The results are shown in Table 1. Of the 450 participants, 68.9% were female (n = 310). 32.0% (n = 144) aged > 65 years; 30.7% (n = 138) had attained tertiary education or above; 34.2% (n = 154) worked full-time; 32.7% (n = 147) had had chronic diseases such as hypertension and diabetes. Also, 20.4% (n = 92) were single (20.4%); 11.8% (n = 53) had had children aged < 18 years.

Table 1
Participants’ background characteristics and behavioral intention of COVID-19 vaccination.

	n	%
Sex		
Female	310	68.9
Male	140	31.1
Age groups (years)		
18–35	63	14.0
36–65	243	54.0
>65	144	32.0
Educational level		
< College	311	69.1
≥ College	138	30.7
Missing data	1	0.2
Current marital status		
Married	316	70.2
Single	92	20.4
Else	42	9.3
Having children under 18		
No	397	88.2
Yes	53	11.8
Employment status		
Full-time	154	34.2
Retired	137	30.4
Housewives	116	25.8
Else	43	9.6
Chronic diseases status [¶]		
No	302	67.1
Yes	147	32.7
Don’t know	1	0.2
Behavioral intention of COVID-19 vaccination		
Free vaccination + 80% effectiveness + Rare and mild side effects		
Definitely not	144	32.0
Probably not	46	10.2
Half-half	89	19.8
Probably yes	153	34.0
Definitely yes	18	4.0
Free vaccination + 50% effectiveness + Rare and mild side effects		
Definitely not	222	49.3
Probably not	123	27.3
Half-half	55	12.2
Probably yes	44	9.8
Definitely yes	6	1.3
Intention of immediate vaccination		
No	391	86.9
Yes	59	13.1

Note: ¶, chronic disease status: whether having chronic diseases such as hypertension, diabetes, chronic pulmonary/heart diseases.

The prevalence of the three types of behavioral intention (probably/definitely yes) of COVID-19 vaccination was low: a) S1: free/rare and mild side effects/80% effectiveness (38.0%; n = 171), b) S2: free/rare and mild side effects/50% effectiveness (11.1%; n = 50), and c) S3: immediate vaccination (13.1%; n = 59).

The overall scale scores (range: 1–5) of the four HAPA constructs are summarized in Table 2. The correlations among the four overall scales of the HAPA constructs are presented in Table 3. They were all significantly associated with each other, with the exception that self-efficacy was not statistically associated with risk perception.

3.2. Background factors of COVID-19 vaccination intention (Table 4)

The results are shown in Table 4. In general, those who were male, older, retired, currently married, had not attended college, and having chronic diseases were significantly more likely than others to give affirmative answers to the three scenarios of behav-

Table 2
Descriptive statistics of HAPA constructs (range = 1–5).

	Mean	SD
Risk perception scale	2.5	0.8
Positive outcome expectancy		
Overall scale	3.3	0.7
Protection effect subscale	3.6	0.7
Restoration of normal life subscale	3.0	0.9
Psychological relief subscale	3.3	1.0
Contribution to Hong Kong subscale	3.4	0.9
Negative outcome expectancy		
Overall scale	2.3	0.8
Causing infection subscale	2.1	0.9
Severe side effects subscale	2.4	1.0
Limited protectiveness subscale	2.4	0.9
Self-efficacy		
Overall scale	3.7	0.9
Confidence subscale	3.7	0.9
Easy to do subscale	3.6	0.9

Note: HAPA, Health Action Planning Approach; SD, Standard deviation.

ioral intention of COVID-19 vaccination. These factors were adjusted for in the subsequent logistic regression analysis.

3.3. Adjusted associations between the four HAPA constructs and the three scenarios of behavioral intention of COVID-19 vaccination in separated models (Table 5)

Risk perception

Multivariable logistic regression analysis showed that risk perception was not significantly associated with any of the three scenarios of behavioral intention, after adjusted for all background factors.

Positive outcome expectancy

- (1) The overall positive outcome expectancy scale was positively associated with the behavioral intention of free vaccination with 80% effectiveness and rare and mild side effects (ORa = 3.03, 95% CI: 2.13–4.30) and intention of immediate vaccination (ORa = 2.31, 95% CI: 1.39–3.85), but not significantly associated with the scenario of free vaccination with 50% effectiveness and rare and mild side effects (ORa = 1.25, 95% CI: 0.77–2.03).
- (2) Considering the four subscales of the dimensions of positive outcome expectancy, a) the 2-item causing infection subscale was positively associated with all three scenarios of behavioral intention. b) The three other subscales of positive outcome expectancy (i.e., the 2-item restoration of normal life subscale, the single-item psychological relief subscale,

and the single-item contribution to Hong Kong subscale) were all positively associated with the behavioral intention of free vaccination with 80% effectiveness and rare and mild side effects (S1) and scenario of immediate vaccination (S3), but not with the behavioral intention of free vaccination with 50% effectiveness and rare and mild side effects (S2).

Negative outcome expectancy

- (1) The overall negative outcome expectancy scale was negatively associated with all the three scenarios of behavioral intention of COVID-19 vaccination (ORa = 0.30 to 0.53; $p < 0.05$).
- (2) The three single-item subscales of the three dimensions of negative outcome expectancy (i.e., causing infection, severe side effects, and limited protectiveness) were, in general, negatively associated with the three scenarios of behavioral intention of COVID-19 vaccination, except that the association between the single-item severe side effect subscale and behavioral intention of free vaccination with 50% effectiveness and rare and mild side effects was statistically non-significant.

Self-efficacy of COVID-19 vaccination

- (1) The overall 2-item self-efficacy scale was significantly (positively) associated with the scenario of free vaccination with 80% effectiveness and rare and mild side effects (ORa = 1.34, 95% CI: 1.04–1.71), but not significantly associated with the other two scenarios of behavioral intention involving 50% effectiveness and immediate vaccination.
- (2) The two single-item subscales of the self-efficacy scale (i.e., the confidence and easy to do subscales) were both positively associated with the scenario of free vaccination with 80% effectiveness and rare and mild side effects, but not significantly associated with the other two scenarios of behavioral intention involving 50% effectiveness and immediate vaccination.

3.4. Summary models

In Table 6, all the four overall scales of the HAPA constructs were entered into the same individual models involving the three scenarios of vaccination intention. 1) Risk perception was not associated with any of the three vaccination intention scenarios. 2) Positive outcome expectancy was significantly associated with two of the three scenarios of intention (except that involved 50% effectiveness). 3) Negative outcome expectancy was significantly associated with all three scenarios. 4) Self-efficacy was not significantly associated with any of the three scenarios.

Table 3
Correlations of the HAPA constructs.

	Risk perception scale	Overall positive outcome expectancy scale	Overall negative outcome expectancy scale	Overall self-efficacy scale
Risk perception scale	–			
Overall positive outcome expectancy scale	0.32***	–		
Overall negative outcome expectancy scale	0.29***	–0.14**	–	
Overall self-efficacy scale	0.03	0.20***	–0.33***	–

Note: HAPA, Health Action Planning Approach.

** , $p < .01$.
*** , $p < .001$.

Table 4
Comparing the background factors between those showing and not showing intention of intention.

	Behavioral intention of COVID-19 vaccination						Intention of immediate vaccination		
	Free/80% effectiveness/Rare and mild side effects			Free/50% effectiveness/Rare and mild side effects/			Yes (%)	No (%)	p
	Probably/ definitely yes (%)	Else (%)	p	Probably/ definitely yes (%)	Else (%)	p			
Sex			0.425			0.006			0.045
Female	36.8	63.2		8.4	91.6		11.0	89.0	
Male	40.7	59.3		17.1	82.9		17.9	82.1	
Age groups (years)			<0.001			<0.001			<0.001
18–35	25.4	74.6		11.1	88.9		4.8	95.2	
36–65	31.7	68.3		5.8	94.2		6.6	93.4	
>65	38.0	45.8		20.1	79.9		27.8	72.2	
Educational level			0.009			0.933			0.003
< College	42.1	57.9		11.3	88.7		16.7	83.3	
≥ College	28.3	71.7		10.9	89.1		5.1	94.9	
Missing data	100.0	0.0		0.0	100.0		0.0	100.0	
Current marital status			0.005			0.395			0.001
Married	39.9	60.1		11.1	88.9		13.6	86.4	
Single	25.0	75.0		8.7	91.3		4.3	95.7	
Else [†]	52.4	47.6		16.7	83.3		28.6	71.4	
Having children under 18			0.064			0.179			0.032
No	39.5	60.5		11.8	88.2		14.4	85.6	
Yes	26.4	73.6		5.7	94.3		3.8	96.2	
Employment status			0.002			0.001			<0.001
Full-time	27.9	72.1		7.1	92.9		8.4	91.6	
Retired	49.6	50.4		19.7	80.3		24.1	75.9	
Housewives	39.7	60.3		5.2	94.8		11.2	88.8	
Else [‡]	32.6	67.4		14.0	86.0		0.0	100.0	
Chronic diseases status			<0.001			0.001			<0.001
No	29.1	70.9		7.3	92.7		7.6	92.4	
Yes	56.5	43.5		19.0	81.0		24.5	75.5	
Don't know	0.0	100.0		0.0	100.0		0.0	100.0	

[†] 'Else' included separated, divorced, widowed, and refused to answer.

[‡] 'Else' included parttime job, underemployment, unemployment, and students.

Table 5
Adjusted associations between the scales/subscales of the HAPA constructs and the three scenarios of behavioral intention of COVID-19 vaccination.

	Behavioral intention of COVID-19 vaccination		
	Free/80% effectiveness / Rare and mild side effects	Free/50% effectiveness / Rare and mild side effects	Intention of immediate vaccination
	ORa (95% CI)	ORa (95% CI)	ORa (95% CI)
Risk perception scale	1.02 (0.79–1.33)	0.67 (0.44–1.01)	0.82 (0.57–1.20)
Positive outcome expectancy			
Overall scale	3.03 (2.13–4.30)***	1.25 (0.77–2.03)	2.31 (1.39–3.85)**
Protection effect subscale	3.45 (2.37–5.02)***	2.36 (1.37–4.07)**	2.14 (1.26–3.64)**
Restoration of normal life subscale	1.81 (1.41–2.31)***	0.93 (0.65–1.32)	1.45 (1.02–2.07)*
Psychological relief subscale	1.75 (1.39–2.21)***	0.91 (0.66–1.25)	1.59 (1.12–2.27)*
Contribution to Hong Kong subscale	1.68 (1.30–2.18)***	1.18 (0.81–1.72)	2.11(1.41–3.14)***
Negative outcome expectancy			
Overall scale	0.53 (0.40–0.70)***	0.39 (0.24–0.64)***	0.30 (0.18–0.49)***
Causing infection subscale	0.59 (0.46–0.75)***	0.43 (0.28–0.66)***	0.34 (0.21–0.53)***
Severe side effects subscale	0.60 (0.48–0.75)***	0.72 (0.51–1.01)	0.40 (0.27–0.60)***
Limited protectiveness subscale	0.67 (0.52–0.87)**	0.36 (0.23–0.59)***	0.46 (0.30–0.70)***
Self-efficacy			
Overall scale	1.34 (1.04–1.71)*	1.03 (0.72–1.48)	0.93 (0.66–1.30)
Confidence subscale	1.32 (1.04–1.69)*	1.06 (0.74–1.52)	0.98 (0.70–1.38)
Easy to do subscale	1.30 (1.03–1.65)*	1.01 (0.72–1.41)	0.90 (0.65–1.22)

Note: HAPA, Health Action Planning Approach; ORa, Adjusted odds ratio; CI, Confidence interval; *, $p < .05$; **, $p < .01$; ***, $p < .001$. The models were adjusted for sex, age, educational level, marital status, having children under 18, employment status, and chronic disease status.

4. Discussion

The prevalence of behavioral intention of COVID-19 vaccination in Hong Kong was low (<40%), even under the 'optimal' scenario that the COVID-19 vaccines exhibit 80% effectiveness and rare mild

side effects (S1). It dropped further to only about 10% if the effectiveness was only 50% (S2), which is the minimum acceptable level of the Federal Drug Association. This drop is understandable as perceived effectiveness is a known predictor of vaccination behaviors [32]. In Hong Kong, free and steadily adequate supply of two types

Table 6
Summary models of the overall scales of the four HAPA constructs and the three scenarios of intention of COVID-19 vaccination.

	Behavioral intention of COVID-19 vaccination		
	Free/80% effectiveness / Rare and mild side effects	Free/50% effectiveness / Rare and mild side effects	Intention of immediate vaccination
	ORm (95% CI)	ORm (95% CI)	ORm (95% CI)
Risk perception scale	0.97 (0.70–1.33)	0.80 (0.49–1.32)	1.04 (0.64–1.68)
Overall positive outcome expectancy scale	2.98(2.03–4.37)***	1.22 (0.69–2.16)	2.64 (1.43–4.85)**
Overall negative outcome expectancy scale	0.57 (0.42–0.79)**	0.43 (0.26–0.71)**	0.30(0.18–0.51)***
Overall self-efficacy scale	0.99 (0.75–1.31)	0.96 (0.62–1.48)	0.70 (0.47–1.04)

Note: HAPA, Health Action Planning Approach; ORm, odds ratio in the summary models entering all the four HAPA constructs and adjusted for the background factors (sex, age, educational level, marital status, having children under 18, employment status, and chronic disease status); CI; Confidence interval; *, $p < .05$; **, $p < .01$; ***, $p < .001$.

of free COVID-19 vaccines (Pfizer-BioNTech-Fosun and Sinovac Biotech) have become available to the general public since February 26, 2021. These two vaccines' efficacy for protection were 95% and 51%, respectively; their effectiveness varied across studies but was often within the range of 50% to 80% [33,34]. This study's two effectiveness scenarios hence align with the actual effectiveness scenario. With online appointment, COVID-19 vaccination could be taken by Hong Kong residents at conveniently located vaccination sites.

The low prevalence of vaccination intention of 40% (S1: given vaccine's effectiveness of 80%) observed about five months prior to the vaccination rollout in Hong Kong thus gave a warning signal to Hong Kong that the vaccination rate in the first six months since the rollout would be quite low, and prompt promotion targeting special groups (e.g., females, younger, and better education people) was warranted. The present study's prevalence of vaccination intention (S1) matches very well with the actual prevalence of completed vaccination of 40% around August 13, 2021 (i.e., about six months since the rollout). The vaccination rate in Hong Kong was sluggish in the first few months since the rollout. It was only 12.2% as of May 1st, 2021; it picked up after June 2021 to reach about 40% in August and then 60% in October 2021. It is possible that the late majority then started vaccinating, according to the Diffusion of Innovation Theory [35]. Other reasons might account for the acceleration. First, more solid scientific evidence about safety of COVID-19 vaccines became available. Second, 'semi-mandatory' vaccination policies have been exercised to some occupational groups (e.g., civil servants, hospital workers, food catering workers, and teachers); unvaccinated workers needed to face huge inconvenience such as bi-weekly COVID-19 testing. Third, vaccination status was associated with waiving some social distancing policies, e.g., larger restaurant tables were only provided to vaccinated customers. The findings suggest that vaccination intention data collected during pre-rollout period might be able to predict short-term vaccination rates during the initial rollout period, but its longer-term accuracy would depend on emerging policies and contextual changes.

The observed low prevalence of COVID-19 vaccination intention can be interpreted contextually, first in terms of low perceived risk. Hong Kong has been extremely vigilant about controlling COVID-19 and has implemented comprehensive public health measures, from compulsory facemask use in public areas to social distancing and travel restrictions. During the study period, there were 112 cumulative new COVID-19 cases and on average only seven cases per day in Hong Kong. Daily life has certainly been negatively impacted, but it remained 'relatively normal'. Hong Kong people might thus not see a pressing need to take up COVID-19 vaccination as a means of protection because of the low incidence of COVID-19, the almost universal use of facemasks in public areas [36], the practice of good hand hygiene [36], and social distancing policies [29]. Such arguments are also supported by the present

study's data. In this sample, the mean risk perception score of 2.5 (range from 1 to 5) implied only moderate perceived risk, which might be lower than that of other highly affected countries. Furthermore, unlike what postulated by HAPA, perceived risk was not significantly associated with the three scenarios of the vaccination intention in this study. Thus, perceived risk did not seem to be the driving force that motivated local people to take up COVID-19 vaccination. It is contended and needs to be confirmed that the emphasis on risk of COVID-19 infection might not be a useful health promotion strategy in countries having 'good control' of the spread of COVID-19.

Although direct international comparisons are not feasible due to methodological differences, the prevalence of intention of COVID-19 vaccination seems much lower than that reported in a number of countries (e.g., Malaysia, mainland China, India, Indonesia, and European countries) during the same time period, which was > 70% to 93.3% [12,15,37–39]. The authors contend that across countries, the prevalence of intention of COVID-19 vaccination might be inversely related to the country's severity of COVID-19 pandemic and positively related to the level of personal protection practice against COVID-19 (e.g., social distancing and face-mask use). No data have substantiated these contentions and research is warranted. China might be an exception of the above contentions, as it had put COVID-19 under control but yet, very high prevalence of intention of COVID-19 vaccination (91.3%) [37], possibly because of collectivism that motivated people's intention of vaccination in China [40]. International perspectives are implicative as the ultimate control of the pandemic requires global immunity.

The prevalence of behavioral intention of COVID-19 vaccination remained low in Hong Kong during the initial post-rollout period (25.1%) [41] while similar data was unavailable in other countries for comparisons. The actual vaccination rate during the initial rollout period in Hong Kong (say May 2021) was lower than those of some seriously affected countries (e.g., U.S. and U.K.) but was comparable to or even higher than others (e.g., Australia, Singapore, Japan, and Thailand) [3]. The vaccination rates of these countries, which are generally characterized by a good supply of vaccines, seem to have converged and reached or exceeded 70% as of November 2021 [3]. In sum, vaccination rates might tend to vary across countries more in the initial than the later phases of the rollout. Availability of vaccines and other factors might have partially accounted for the inter-country differences observed in the initial rollout phase.

Another interesting finding is that even about 40% had indicated an intention of vaccination under the 'optimal' scenario (S1), only about 13% would like to take up COVID-19 vaccination at the soonest (S3). This relatively low prevalence under S3 is understandable given the uncertainties and some news about severe side effects of COVID-19 vaccination, including deaths [42]; people would like to observe first before taking up the vaccination. It is unknown

whether the high intention of vaccination observed in a number of countries in literature [12,15,38,39] implied mostly immediate vaccinations or vaccination after prolonged observation periods, as no study of other countries has asked about the intended timing of COVID-19 vaccination. Timing is an important piece of information supplementing that about COVID-19 vaccination intention.

The descriptive figures suggest that the level of the positive outcome expectancies were moderate [protection effect (3.6), contribution to Hong Kong (3.4), psychological relief (3.3), and restoration of normal life (3.0); range = 1 to 5]. The moderate level may also partially explain the low level of the intention of COVID-19 vaccination. Furthermore, the benefits directed to others (contribution to Hong Kong) were as high as or higher than the personal benefits (psychological relief and restoration of normal life). It is plausible that control of COVID-19 at the community level would mean resumption of the economy and thus personal benefits. Health promotion of COVID-19 vaccines should thus emphasize both personal and community gains.

Except for the protection effect subscale of positive outcome expectancy that was significantly associated with both scenarios of intention involving 80% and 50% effectiveness (S1 and S2), the other three subscales of positive outcome expectancies were significantly associated with the intention that involved 80% effectiveness (S3) but not that of 50% effectiveness (S2). This is again understandable as vaccines of 50% effectiveness might not be able to result in the positive outcomes of psychological relief, restoration of normal life, and control of the local COVID-19 pandemic. The implication of health promotion is that emphasis on positive expectancy would be warranted and potentially effective only when COVID-19 vaccines are highly effective. Otherwise, emphasis on positive expectancies of COVID-19 vaccination might be ineffective.

Regarding negative outcome expectancies, the mean values (range = 1 to 5) of the single-item subscales were: vaccination causing infection (2.1), limited protectiveness (2.4), and severe side effects (2.4). Thus, it is apparent that in general the participants did not find such potential negative outcomes worrisome. Nevertheless, the adjusted analysis showed that the three dimensions of negative outcome expectancies were all significantly associated with the three scenarios of the intention of COVID-19 vaccination (S1-S3), except that the perceived severe side effect subscale that was not significantly associated with the intention of free vaccination that involved 50% effectiveness (S2). Thus, health promotion for COVID-19 vaccination (and prompt vaccination) should focus on reducing negative outcome expectancies, although such levels were modest in Hong Kong. It is noteworthy that the levels of negative outcome expectancies (e.g., limited protectiveness and perceived severe side effects) are subjected to emerging evidence and developments. The implications are that, first, surveillance of intention of COVID-19 vaccination and associated factors would be useful as improvement in effectiveness and incidents of severe side effects are expected to occur over time. Second, country variations may exist as it is likely that they would use different types of vaccines; international comparisons are warranted.

Self-efficacy of vaccination was only significant (in S1) in the adjusted analysis that treated it as the single independent variable, but not in the summary model that included all four overall scales of the HAPA. Thus, the association between self-efficacy and intention of vaccination (S1) became non-significant after adjusted for the positive/negative outcome expectancies. It is plausible that self-efficacy was empirically associated with positive/negative outcome expectancies in this study, as those with favorable outcome expectancies might encounter less psychological barriers toward vaccination, and thus possess higher self-efficacy. The mean values of the two self-efficacy subscales were modest (3.6 and 3.7). Since the logistics of COVID-19 vaccination is unknown at this stage, self-

efficacy might not be a reliable construct. At this stage, promotion of self-efficacy seems pre-mature. Future studies are required to confirm the level of self-efficacy and its relationship with COVID-19 vaccination when vaccinations are made available to the public. The discrepancy that self-efficacy was significant in the individual models that did not contain the other three HAPA constructs but were non-significant in the models containing all the four HAPA constructs was possibly due to significant interrelationships among the four HAPA constructs. For instance, self-efficacy was associated with both positive and negative outcome expectancy. In this study, multi-collinearity among the independent variables were non-significant as the Variance Inflation Factors were < 5 (ranged from 1.16 to 1.28).

This study may be the first one that applies the pre-intentional motivational phase of the HAPA to understand behavioral intentions of COVID-19 vaccination. The model was partially supported by the data. It seems that outcome expectancies, especially negative outcome expectancies, were more important than risk perception and self-efficacy to influence the intention of COVID-19 vaccination. Outcome expectancy is also a construct of the Social Cognitive Theory [43]. It is potentially an important part of health promotion to increase COVID-19 vaccination.

Pre-rollout COVID-19 vaccination intention studies were commonly subjected to some limitations. Importantly, their questions about vaccination intention tended to be general and did not refer to specific levels of efficacy and safety of the vaccines (e.g., “If the government will provide a free-of-charge COVID-19 vaccine within the next 12 months, will you receive it?” [44]), possibly because information about efficacy and safety were not available during the data collection periods. As perceived efficacy/safety of vaccines strongly affected vaccination decisions [7], the absence of such references might have reduced reliability and validity of the responses about vaccination intention. A contribution of the present study is that it specified conditions of the vaccine’s efficacy/safety when asking the vaccination intention questions. Such referencing contexts improved interpretability of the findings.

This study has some other limitations. First, the cross-sectional study design does not allow for making causal inferences. Second, in the absence of existing scales on the HAPA constructs in the context of COVID-19 vaccination intention, the measurements of the HAPA were self-constructed in accordance with the guideline proposed by the HAPA developer [45]. A panel of behavioral scientist, epidemiologist, and psychologist was formed to decide on the dimensions and items of the HAPA constructs. Furthermore, as outcome expectancies are multi-dimensional, some dimensions may have been missed and some subscales were single-itemed. Although the purpose of this study was not to generate a new outcome expectancy scale for COVID-19 vaccination, such efforts are warranted. Third, although we asked the intention of COVID-19 vaccination that varied in effectiveness (80% versus 50%), we fixed the conditions of safety; other scenarios (e.g., low effectiveness and relatively common mild side effects) were not investigated in this study. It is a potential limitation that S3 (immediate vaccination intention) did not specify efficacy and safety. Fourth, although the response rate (51.4%) was comparable to other local telephone surveys [28,29], the responses between the participants and non-participants may differ. However, characteristics of non-participants were not collected; comparisons between participants and non-participants hence cannot be made. As COVID-19 vaccination may be socially desirable, reporting bias might have occurred. If such is true, the actual prevalence of intention would even be lower than that reported.

In conclusion, the pre-rollout prevalence of behavioral intention to take up COVID-19 vaccination was alarmingly low in the Hong Kong general adult population. Efforts are greatly warranted to improve vaccination intention through health promotion programs

that should modify the positive and negative outcome expectancies of COVID-19 vaccination. Pre-rollout vaccination data might be able to ‘predict’ vaccination rate during the initial rollout period; subsequent trajectories of the vaccination rates are, however, likely to depend on emerging country-specific policies. As COVID-19 vaccination depends on contextual and geographical factors, generalization to other countries need to be cautious. Furthermore, vaccination intention is also subjected to temporal changes, which would in turn be affected by changing contextual factors. Future studies are warranted to confirm the findings of this study across countries and time periods. Longitudinal studies may apply the full HAPA to understand COVID-19 vaccination. This study has built up the foundation for such studies and allows for international comparisons.

CRediT authorship contribution statement

Yanqiu Yu: Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Wanru Jia:** Writing – original draft, Writing – review & editing. **Mason M.C. Lau:** Investigation. **Joseph T.F. Lau:** Conceptualization, Methodology, Validation, Resources, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethic statement

The study was approved by the Survey and Behavioral Research Ethics Committee of the Chinese University of Hong Kong (No. SBRE-20-034).

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