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RESEARCH PAPER

Facilitators and barriers to completing recommended doses of pneumococcal vaccination among community-living individuals aged ≥65 years in Hong Kong – a population-based study

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ABSTRACT

Individuals aged ≥65 y are recommended to receive pneumococcal vaccination (PV). PV completion is defined as receiving two doses of PV among those with at least one high-risk condition for severe invasive pneumococcal diseases (IPD) or receiving one dose of PV among those without any high-risk conditions. This study investigated factors associated with PV completion among a random sample of community-living older adults in Hong Kong, China. In addition, factors associated with receiving a single dose of PV among older adults with at least one high-risk condition were also investigated. A total of 750 community-living Chinese-speaking individuals aged ≥65 y in Hong Kong (response rate: 63.4%) completed a random telephone survey from May to July 2019. PV completion was 10% among all participants. Among participants with high-risk condition(s) for severe IPD, 11.4% received a single dose of PV. After adjustment for significant background variables, several Health Belief Model constructs were significantly associated with both dependent variables: (1) perceived risk of contracting pneumococcal diseases, (2) perceived benefits of PV for protecting themselves or others, (3) perceived barriers to PV uptake, (4) being suggested by significant others to take up PV (cue to action), and (5) confidence to take up PV (perceived self-efficacy). In addition, being knowledgeable about pneumococcal diseases and vaccination, and knowing at least one peer of similar age who had taken up PV were also positively associated with both dependent variables. Targeted, theory-based health promotion efforts are needed to increase PV coverage among elderly in Hong Kong.

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Introduction

Streptococcus pneumoniae causes a wide spectrum of diseases and is the most common cause of community-acquired pneumonia.[1] In most patients, it causes noninvasive diseases such as otitis media, sinusitis, and pneumonia.[1] The infection may also spread into the bloodstream, causing invasive pneumococcal diseases (IPD), including sepsis, meningitis, and bacteremic pneumonia.[1] Worldwide, pneumococcal diseases (PD) cause 1.6 million deaths annually.[2] In the United States, about 900,000 people contract pneumococcal pneumonia every year.[3] In Hong Kong, China, pneumonia is the second leading cause of death, [4] and the annual incidence of IPD ranges from 1.7 to 2.9 per 100,000.[5] Individuals aged ≥65 y are at much higher risk of PD and IPD, [3,6] and have the highest risk of death from IPD.[3,6] The incidence of IPD is higher among individuals aged ≥65 y; this age group accounted for 44.6% (83/186) of reported IPD cases in 2016.[7] Older adults with the following health conditions or history are more vulnerable to severe IPD: (1) history of IPD, (2) immunocompromised states, (3) chronic diseases (chronic cardiovascular, lung, liver, or kidney diseases, diabetes mellitus, and cerebrospinal fluid leakage), and (4) having a cochlear implant.[5]

The 13-valent pneumococcal conjugate vaccines (PCV13) and the 23-valent pneumococcal polysaccharide vaccine (23vPPV) are effective in preventing vaccine-type community-acquired pneumonia (vaccine efficacy: 45.6%), pneumococcal pneumonia (vaccine efficacy: 63.8%) and IPD (vaccine efficacy: 65–75%) among individuals aged ≥65 y.[8–10] Both types of pneumococcal vaccination (PV) are available in Hong Kong and their safety is well documented.[11] Across diverse settings, the provision of free PV to older adults is a cost-effective prevention measure, [12,13] and is projected to save USD 18.0 million in health expenditures in Hong Kong.[14] In line with other international health authorities, the Hong Kong Department of Health recommends that individuals aged ≥65 y without the aforementioned high-risk conditions receive a single dose of PCV13 or 23vPPV. Those with at least one high-risk condition for severe IPD but have no PV history are recommended to receive one dose of PCV13 followed by one dose of 23vPPV 1 y later.[5]

In October 2017, the Vaccination Subsidy Scheme and Government Vaccination Program were launched in Hong Kong, providing free or subsidized PV to eligible groups, but there is little information on program outcomes for

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community-living older adults. Under these programs, community-living Hong Kong residents aged ≥65 y with high-risk condition(s) for severe IPD are eligible for free PV from public health-care providers, and all community-living Hong Kong residents aged ≥65 y can also receive subsidized PV at enrolled private doctors regardless of medical history (PCV13: HK$730/dose; 23vPPV: HK$190/dose).[5] For older adults in a residential care facility, free PV is provided on-site.[5] The Hong Kong Social Welfare Department provides residential care services to elderly aged ≥65 y. These services include homes for the aged, care and attention homes, and nursing homes. Homes of the aged provide accommodation, at least three meals a day, social work services, and assistance in daily living activities. On top of these services, the care and attention homes and nursing homes provide nursing services and regular visit of registered practitioners. Elderly can submit application to the Social Welfare Department and the services cost HK$1,481–2,060 per month. By the end of 2019, 33,278 elderly aged ≥65 y were living in these residential care homes.[2] A prior study reported that 58% of elderly in residential care homes had a history of PV.[15] However, there is a lack of published data on PV uptake among community-living elderly in Hong Kong.

In order to develop effective health promotion campaigns, it is important to understand the facilitators and barriers of PV uptake and completion among community-living older adults in Hong Kong. Previous studies have found a number of factors associated with PV uptake specifically among community-living individuals aged ≥65 y in other settings, including socio-demographics (e.g., age, gender, household income, health insurance, and living arrangement), [16] presence of comorbid conditions (e.g., chronic heart/lung/diseases, diabetes mellitus, asthma) and lifestyle risk factors (e.g., smoking), [17] history of influenza vaccination, awareness of PV and recommendation of PV for older people, [16,18] and perceptions related to pneumonia (e.g., perceived severity about consequences of pneumonia) and PV (perceived efficacy, concerns of safety and side effects, cost of vaccination, advices from family members, physicians and friends regarding vaccination).[19]

Theory-based interventions are more effective than those that are not.[20] In this study, we applied the Health Belief Model (HBM)[21] as the theoretical framework. The HBM postulates that perceived susceptibility and perceived severity regarding consequences of PD and IPD, and perceived benefits, perceived barriers, cue to action, and perceived self-efficacy regarding PV are determinants of PV uptake. In published studies, the HBM has been successfully used to explain vaccination uptake among the general population and older adults.[22–24]

In addition to HBM constructs, factors related to older adults' social media use and social networks may also influence PV uptake. The use of social media, referring to websites or apps that enable users to create and share content or to participate in social networking, has increased sharply in Hong Kong. Official data showed that 78% of Hong Kong residents aged ≥45 y used social media in 2018.[25] Across countries, it is common to encounter information related to vaccination on social media.[26] In addition, older adults' attitudes toward PV and their decision whether to take up PV may be influenced by other social network-related factors such as their peers' attitudes and behaviors. Studies suggest that communication among elderly is very effective due to higher level of rapport between people of similar age.[27] Older adults usually prefer to seek information from other older adult individuals, who are perceived as providing more credible information than other potential sources.[28]

Most of the published studies investigating facilitators and barriers of PV uptake among elderly were conducted in western countries. To the best of our knowledge, there have been no studies investigating PV uptake and potentially associated factors among community-living elderly in China. To address these gaps, this study investigated the prevalence of and factors associated with completing recommended doses of PV among a random sample of community-living individuals aged ≥65 y in Hong Kong. In addition, factors associated with receiving a single dose of PV among elderly with at least one high-risk condition of severe IPD were also investigated. The potentially associated factors included their background characteristics, knowledge, and perceptions related to PV, exposure to information supporting PV on social media, and the number of peers who have taken up PV.

Materials and methods

Participants and data collection

Participants were community-living Chinese-speaking individuals aged ≥65 y and had a Hong Kong ID card. Those who were not able to communicate effectively with the interviewers were excluded. A random telephone survey was conducted by trained interviewers. Telephone numbers were selected from up-to-date Hong Kong telephone directories. Interviews were conducted between 6:00–10:00 pm on weekdays and 2:00–9:00 pm on Saturdays from May to July 2019. If no one in the household answered the initial call, four more follow-up calls were made at different hours and days before it was considered as a non-valid household (one without an eligible participant). If there was more than one person in the household aged ≥65 y, the person whose last birthday was closest to the date of the interview was invited to join the study. Prospective eligible participants were briefed about the study. Participants were informed that their responses would be anonymous that they had the right to withdraw from the study at any time, and that refusal to participate would not affect their access to services. Verbal instead of written informed consent was obtained in order to protect confidentiality, and all interviewers signed a form pledging that the participants had been fully informed about the study. The telephone interview took about 20 minutes to complete. Out of 1183 eligible participants, 750 (response rate: 63.4%) provided verbal informed consent and completed the anonymous telephone survey. No incentive was provided to the participants. Ethics approval was obtained from the Survey and Behavioral Research Ethics Committee of the Chinese University of Hong Kong (Reference No. SBRE-19-183).

Measures

Development of the questionnaire

A panel consisting of researchers and experts in public health, behavioral health, pneumococcal diseases and vaccination, and health psychology was formed to design the questionnaire used

in the current study. The questionnaire was pilot tested among 20 eligible elderly to assess clarity and readability. Based on participant comments, the questionnaire was revised and finalized by the panel.

Background characteristics

Participants were asked to report on socio-demographics (age, gender, highest education level attained, marital status, current employment status, monthly household income, whether they were living alone) and lifestyles (smoking and binge drinking in the past year). Participants were also asked about their history of high-risk conditions for severe IPD listed by the Hong Kong Department of Health, [5] and history of pneumonia and seasonal influenza vaccination.

Completing recommended doses of PV (PV completion)

Following local health department guidelines, PV completion was defined as: (1) had taken two doses of PV among those with at least one high-risk condition for severe IPD as defined by the Hong Kong Department of Health or (2) had taken up one dose of PV among those without any of the aforementioned high-risk conditions.[5] PV completion was assessed by measuring the number of PV doses taken by participants, and supplementary information such as date and location of PV was collected.

Knowledge and perceptions related to PD and PV

Seven items were used to assess knowledge related to PD and PV. A composite indicator variable was constructed by counting the number of correct responses reflecting knowledge related to PD and PV (ranged from 0 to 7).

Four scales based on the HBM were constructed for this study. Perceived susceptibility to PD was measured by two items (e.g., 'how high is your chance of having pneumonia without taking up PV?') (Response categories: 1 = very low to 5 = very high). The Perceived Susceptibility Scale was formed by summing up individual item scores, with higher scores indicating perceived higher susceptibility to PD (ranging from 2 to 10). Perceived benefit of PV for oneself and for others were assessed using three items, and two items, respectively. The Perceived Benefit for Oneself Scale and the Perceived Benefit for Others Scale were constructed by summing up individual item scores (response categories: 1 = disagree, 2 = neutral, 3 = agree). Higher scores in these two scales indicated perceived PV uptake had more benefit for oneself (ranging from 3 to 9) and for others (ranging from 2 to 6). Perceived barriers to PV uptake were measured by three items (e.g., 'you are concerned about the side-effects of PV', response categories: 1 = disagree, 2 = neutral, 3 = agree). The Perceived Barrier Scale was formed by summing up individual item scores (ranging from 3 to 9), with higher scores indicating greater levels of perceived barriers to PV uptake. In addition, two single items were used to measure cue to action ('your significant others suggest you to take up PV') and perceived self-efficacy related to PV ('you are confident to take up PV if you want') (response categories: 1 = disagree, 2 = neutral, 3 = agree).The Cronbach's alpha of these scales ranged from 0.650 to 0.920. Single factors were identified by exploratory factor analysis (EFA), explaining 67.6–91.8% of total variances.

Exposure to information supporting PV on social media

Four items measured frequency of exposure to information supporting PV on social media (e.g., WeChat, Weibo, WhatsApp, Facebook, and Instagram) was asked (response categories: 1 = never, 2 = seldom, 3 = sometimes, 4 = always). The Social Media Influence Scale was formed by summing up individual item scores, with higher scores indicating higher exposure to information supporting PV on social media. The Cronbach's alpha for this scale was 0.704, and a single factor was identified by EFA, explaining for 70.1% of total variance.

Number of peers who had taken up PV

Participants were asked about the number of peers of similar age who had received PV (response categories: 0, 1–2, 3–5, >5, uncertain). Those having at least one vaccinated peer were further asked about whether such peer(s) suffered from severe side effects of PV or pneumonia after receiving PV.

Statistical analysis

We used logistic regression models to obtain crude odds ratios (ORs) with PV completion (among all participants), and receiving a single dose of PV (among participants with at least one risk condition of severe IPD who had not completed the two recommended doses of PV) as the dependent variables, and demographic characteristics as independent variables. After adjusting for variables with $p < .05$ in the univariate analysis, associations between independent variables of interest (i.e., knowledge, perceptions, influence of social media, and peers) and the dependent variables were then assessed by adjusted OR (AOR). All AORs were obtained by fitting a single logistic regression model, which involved one of the independent variables of interest and the significant background variables. SPSS version 21.0 was used for data analysis, with p values <.05 considered statistically significant.

Results

Background characteristics

Most participants were more than 70 y old (66.1%), female (60.7%), did not receive tertiary education (79.9%), with monthly income level lower than HK$20,000 or receiving CSSA (96.9%), and living with another person (86.5%). Among participants, 0.5% and 0.3% reported smoking and binge drinking in the past year, respectively. A total of 64.4% participants had at least one high-risk condition of severe IPD listed by the Department of Health, and 50.4% reported having a history of influenza vaccination (Table 1).

PV completion

Among participants, 130 (17.3%) had taken at least one dose of PV. The majority of the vaccinated participants (n = 130) received PV in public hospitals (75.3%), while fewer received PV in private clinics (10.8%), community or elderly centers (7.7%), or other organizations (6.2%). Around 81.5% received PV within the past 2 y.

Table 1. Background characteristics of a random sample of community-living older adult participants in Hong Kong (n = 750).

	n	%
Socio-demographics		
Age group (years)		
65–70	254	33.9
71–80	311	41.5
>80	185	24.7
Gender		
Male	295	39.3
Female	455	60.7
Highest education level attained		
Primary school or lower	599	79.9
Secondary school	126	16.8
High school diploma/undergraduate or higher	25	3.3
Marital status		
Married/cohabitation	531	70.8
Unmarried/divorced/widowed	219	29.2
Current employment status		
Full-time/part-time	38	5.1
Unemployed/retired/homemakers	712	94.9
Monthly household income (HK$)		
Receiving CSSA[b]	38	5.1
<20,000	689	91.8
≥20,000	23	3.1
Living alone		
No	649	86.5
Yes	101	13.5
Lifestyle		
Cigarette smoking in the past year		
No	746	99.5
Yes	4	0.5
Binge drinking in the past year		
No	748	99.7
Yes	2	0.3
Self-reported high-risk conditions for invasive pneumococcal diseases listed by the Hong Kong Department of Health (% Yes)		
Invasive pneumococcal diseases	2	0.3
Cerebrospinal fluid leakage	2	0.3
Chronic cardiovascular diseases	451	60.1
Chronic lung diseases	1	0.1
Chronic liver diseases	0	0
Chronic kidney diseases	5	0.7
Diabetes Mellitus	139	18.5
Immunocompromised states	1	0.1
Number of high-risk conditions for severe invasive pneumococcal diseases		
0	267	35.6
1	336	44.8
2–3	146	19.5
≥4	1	0.1
History of pneumonia and vaccination		
History of pneumonia		
No	744	99.2
Yes	6	0.8
Family member/friend had history of pneumonia		
No	741	98.8
Yes	9	1.2
Uptake of seasonal influenza vaccination		
No	372	49.6
Yes	378	50.4
Pneumococcal vaccination (PV) completion		
Number of doses of PV taken up by participants with at least one high-risk condition listed by the Department of Health (n = 483)		
0	397	82.2
1	55	11.4
2	31	6.4
Number of doses of PV taken up by participants without any high-risk condition listed by the Department of Health (n = 267)		
0	223	83.5
≥1	44	16.5
PV completion among all participants[a]		
No	675	90.0
Yes	75	10.0

[a]PV completion is defined as: (1) completing two doses of PV among those with at least one high-risk condition listed by the Department of Health or (2) completing at one dose of PV among those without any high-risk condition.

[b]CSSA: Comprehensive Social Security Assistance, referring to a governmental financial support scheme providing a safety net for those who cannot support themselves financially.

The prevalence of PV completion was 10.0% among all participants. The proportion was 16.5% (44/267) among participants without any high-risk conditions for severe IPD. Among those with any high-risk conditions (n = 483), 55 (11.4%) received one dose of PV, and 31 (6.4%) completed both doses of PV (Table 1).

Knowledge, perception, influence of social media, and peers related to PD/PV

Only 10.4% of the participants were considered knowledgeable about PD and PV, defined as those who provided at least six correct responses to seven knowledge items. Among the participants, 28.6–33.3% had been exposed to information supporting PV on social media, and 19.2% reported at least one peer of similar age had taken up PV (Table 2).

Factors associated with completing recommended doses of PV

In the univariate analysis, older age, higher education level, and history of seasonal influenza vaccination were associated with a higher likelihood of PV completion. Those with at least one high-risk condition for severe IPD reported lower PV completion compared to those with no high-risk conditions (Table 3).

After adjustment for age, education, influenza vaccination history, and risk conditions, all constructs of the HBM were significantly associated with the dependent variable in the expected directions. Those who perceived a higher risk of having PD (AOR: 1.49, 95%CI: 1.17, 1.88), believed that PV was beneficial for themselves (AOR: 3.48, 95%CI: 2.41, 5.03) or for others (AOR: 3.06, 95%CI: 2.18, 4.29), had been suggested by significant others to take up PV (AOR: 8.24, 95%CI: 3.09, 22.00), and had higher confidence of taking up PV (AOR: 15.92, 95%CI: 6.42, 39.46) were more likely to complete the recommended doses of PV. The Perceived Barrier Scale score was negatively associated with the dependent variable (AOR: 0.36, 95%CI: 0.27, 0.48). In addition, having better knowledge related to PD/PV (6–7 correct responses: AOR: 13.72, 95%CI: 4.44, 42.40; 3–5 correct responses: AOR: 43.00, 95%CI: 12.05, 153.41; reference group: 1–2 correct responses) and at least one peer of similar age who had taken up PV (AOR: 16.61, 95%CI: 8.14, 33.91) were also associated with higher PV completion. The association between exposure to information supporting PV on social media and PV completion was of marginal statistically significant (Table 4).

Factors associated with receiving a single dose of PV among participants at high risk for severe IPD

In this sub-group of participants, those who were older had higher education level and reported history of influenza vaccination was more likely to have received a single dose of PV.

Table 2. Item responses of knowledge and perceptions related to pneumococcal vaccination (PV) (n = 750).

	%	Mean (SD)
Knowledge related to pneumococcal diseases and PV		
Whether diseases caused by *Streptococcus pneumoniae* have more severe consequences among elderly individuals		
No	1.7	
Yes*	59.9	
Uncertain	38.4	
Whether healthy people can carry *Streptococcus pneumoniae*		
No	9.0	
Yes*	22.5	
Uncertain	68.5	
Whether *Streptococcus pneumoniae* can be transmitted distantly in the air (e.g., from one building to another)		
No*	10.4	
Yes	7.5	
Uncertain	82.1	
Whether pneumococcal pneumonia can be cured by antibiotics		
No	7.4	
Yes*	12.7	
Uncertain	79.9	
Whether influenza infection would increase the risk of pneumococcal pneumonia		
No	1.6	
Yes*	46.7	
Uncertain	51.7	
Whether Hong Kong SAR government recommends elderly individuals aged ≥65 y to take up PV		
No	8.3	
Yes*	58.5	
Uncertain	33.2	
Whether public hospitals/clinics provides free PV to elderly individuals aged ≥65 y		
No	3.3	
Yes*	38.0	
Uncertain	58.7	
Number of correct responses to knowledge items related to pneumonia and PV		
1–2	36.5	
3–5	53.1	
6–7	10.4	
Perceptions related to pneumococcal diseases and PV		
Perceived susceptibility to pneumococcal diseases without taking up PV (% high/very high)		
Chance of having pneumonia	28.8	
Chance of having severe invasive pneumococcal diseases (e.g., septicemia or meningitis)	26.7	
Perceived Susceptibility Scale		6.4 (1.3)
Perceived benefit of PV for oneself (% agree)		
PV is highly effective in preventing you from pneumonia	43.5	
PV is highly effective in preventing you from severe invasive pneumococcal diseases (e.g., septicemia or meningitis)	14.3	
You will feel at ease after taking up PV	52.4	
Perceived Benefit for Oneself Scale		6.8 (1.5)
Perceived benefit of PV for others (% agree)		
Taking up PV is highly effective in preventing pneumonia transmission in Hong Kong	34.4	
Taking up PV is highly effective in protecting your family members against pneumonia	35.1	
Perceived Benefit for Others Scale		
Perceived barrier of taking up PV (% agree)		
PV is expensive for you	16.1	
You concerned about side-effects of PV	18.9	
The time and venue of PV is inconvenient for you	8.4	
Perceived Barrier Scale		5.1 (1.6)
Perceived cue to action related to PV		
Your significant others suggest you to take up PV		
Disagree/neutral	56.0	
Agree	44.0	
Perceived self-efficacy related to PV		
You are confident to take up PV if you want		
Disagree/neutral	39.1	
Agree	60.9	
Peer influence related to PV		
Number of peers of similar age who have taken up PV		
0	39.2	
1–2	12.8	
3–5	4.8	
>5	1.6	
Uncertain	41.6	
Having peers of similar age who have taken up PV and had severe side-effects (among those who had at least one peer who had taken up PV, n = 144)		
No	95.1	
Yes	4.9	
Having peers of similar age who were infected with pneumonia after receiving PV (among those who had at least one peer who had taken up PV, n = 144)		
No	99.3	
Yes	0.7	
Social media influence related to PV		
Exposure to the information supporting PV on social media (% seldom/sometimes/always)		
Elderly people shared their experience to support PV	33.3	
Friends or family suggested you to receive PV through social media	30.0	
Report about elderly individuals had severe conditions or died of pneumonia (R)	40.0	
Commentary or introduction about PV services provided by government for elderly people	28.6	
Social Media Influence Scale		4.1 (0.5)

*Correct response.
R: reverse scoring.

Being married or cohabited with spouse and living alone were negatively associated with the dependent variable (Table 3).

After adjusting for these significant background variables, those who perceived higher susceptibility to PD (AOR: 1.64, 95%CI: 1.22, 2.22), believed that PV was more beneficial for themselves (AOR: 3.22, 95%CI: 2.08, 4.97) or for others (AOR: 2.54, 95%CI: 1.79, 3.61), had significant others suggest PV (AOR: 79.58, 95%CI: 8.21, 540.48), and had higher confidence for taking up PV (AOR: 17.85, 95%CI: 4.16, 76.53) were more likely to receive one dose of PV. Having better knowledge related to PD/PV (6–7 correct responses: AOR: 87.23, 95%CI: 9.89, 769.75; 3–5 correct responses: AOR: 32.32, 95%CI: 4.27, 244.46; reference group: 1–2 correct responses) and at least one peer of similar age who had taken up PV (AOR: 16.61, 95%CI: 8.14, 33.91) were also positively associated with this dependent variable. In addition, a negative association between perceived barriers to take up PV and this dependent variable was found (AOR: 0.30, 95%CI: 0.20, 0.44).

Discussion

This study evaluated key outcomes of the Vaccination Subsidy Scheme and the Government Vaccination Program in Hong Kong. The prevalence of PV completion among community-living individuals aged ≥65 y in Hong Kong was 10%, which was much lower than that of some developed countries/regions, such as the United States (64.0–74.7%), [29] Canada (58.0%),[30] and Australia (43.2–72.8%).[31] High coverage of PV is essential to achieve its effectiveness at the population level.[32] Effective health promotion to increase PV uptake and completion is therefore needed.

Table 3. Associations between participants' profiles and PV uptake.

	PV completion (among all participants, $n = 750$)		Received a single dose of PV (among participants having at least one high-risk condition of severe pneumococcal diseases who had not completed two recommended doses of PV, $n = 452$)	
	Row%	OR (95%CI)	Row%	OR (95%CI)
Socio-demographics				
Age group (years)				
65–70	5.9	1.0	8.8	1.0
71–80	11.6	2.09 (1.11, 3.90)*	16.9	2.10 (1.07, 4.11)*
>80	13.0	2.38 (1.21, 4.67)*	10.7	1.23 (0.56, 2.69)
Gender				
Male	13.2	1.0	13.9	1.0
Female	9.9	0.97 (0.60, 1.58)	11.0	0.77 (0.44, 1.36)
Highest education level attained				
Primary school or lower	9.0	1.0	10.7	1.0
Secondary school	15.1	1.79 (1.02, 3.15)*	21.8	2.33 (1.14, 4.77)*
High diploma/undergraduate or higher	8.0	0.88 (0.20, 3.82)	14.3	1.39 (0.30, 6.43)
Marital status				
Unmarried/divorced/widowed	9.6	1.0	14.2	1.0
Married/cohabitation	10.2	1.07 (0.63, 1.81)	7.4	0.48 (0.23, 0.98)*
Current employment status				
Unemployed/retired/housewives	10.3	1.0	5.6	1.0
Full-time/part-time	5.3	0.49 (0.12, 2.06)	12.4	2.42 (0.31, 18.52)
Monthly household income (HK$)				
Receiving CSSA[a]	2.6	1.0	9.4	1.0
<20,000	10.7	4.45 (0.60, 32.93)	12.1	1.33 (0.39, 4.53)
≥20,000	0.0	N.A.	20.0	2.42 (0.43, 13.71)
Living alone				
No	10.5	1.0	13.6	1.0
Yes	6.9	0.64 (0.28, 1.43)	5.1	0.34 (0.12, 0.98)*
Lifestyles				
Cigarette smoking in the past year				
No	9.9	1.0	12.2	1.0
Yes	25.0	3.03 (0.31, 29.47)	0.0	N.A.
Binge drinking in the past year				
No	9.9	1.0	12.2	1.0
Yes	50.0	9.11 (0.56, 147.13)	0.0	N.A.
History of pneumonia and influenza vaccination				
History of pneumonia				
No	9.9	1.0	12.1	1.0
Yes	16.7	1.81 (0.21, 15.71)	25.0	2.43 (0.25, 23.80)
Family member/friend had history of pneumonia				
No	9.9	1.0	12.1	1.0
Yes	22.2	2.61 (0.53, 12.82)	25.0	2.43 (0.25, 23.80)
Uptake of seasonal influenza vaccination				
No	0.8	1.0	0.4	1.0
Yes	19.0	28.94 (9.03, 92.77)***	23.6	68.50 (9.38, 500.10)***
Having at least one high-risk conditions of severe pneumococcal diseases				
No	16.5	1.0		
Yes	6.4	0.35 (0.21, 0.57)***	–	–

OR: crude odds ratios.
*$P < 0.05$, ***$P < 0.001$.
N.A.: not applicable – not considered by the model.
[a]CSSA: Comprehensive Social Security Assistance. It is a governmental financial support scheme providing a safe net for those who can not support themselves financially.

Participants with and without high-risk conditions for severe IPD reported a similar prevalence of PV uptake. However, a significant proportion of vaccinated participants with such high-risk conditions had not yet received the second dose of PV, resulting in significantly lower levels of PV completion in this group compared to those without high-risk conditions. Given these low levels of PV completion despite high disease risk, future interventions should target older adults at a high risk of IPD. Health communication messages should emphasize that those at risk are recommended to complete both doses to obtain sufficient protection.[5] Consistent with previous studies, elderly with a history of influenza vaccination were more likely to receive the first dose of PV and reported a higher completion rate compared to those without an influenza vaccination history.[16,18] Secondary and co-infection of pneumonia during seasonal influenza is common and associated with a higher risk of death compared to contracting influenza only.[33–35] Delivering PV and influenza vaccination together has been shown to be beneficial in preventing additional hospitalization and mortality among the elderly, [36] and should be implemented in Hong Kong for those aged 65 y or above.

The findings provided empirical insights for developing future rigorous, theory-based interventions. Similar strategies can be used to promote initiating the first dose of PV among elderly with high-risk conditions of severe IPD and to promote

Table 4. Factors associated with PV uptake.

	PV completion (among all participants, n = 750)		Received a single dose of PV (among participants having at least one high-risk condition of severe pneumococcal diseases who had not completed two recommended doses of PV, n = 452)	
	OR (95%CI)	AOR (95%CI)	OR (95%CI)	AOR (95%CI)
Knowledge related to pneumococcal diseases and PV				
Number of correct responses to knowledge items related to pneumococcal diseases and PV				
1–2	1.0	1.0	1.0	1.0
3–5	9.70 (3.46, 27.19)***	13.72 (4.44, 42.40)***	37.60 (5.11, 276.22) ***	32.32 (4.27, 244.46) ***
6–7	24.87 (8.22, 75.22)***	43.00 (12.05, 153.41) ***	85.22 (10.71, 677.99) ***	87.23 (9.89, 769.75) ***
Perceptions related to pneumococcal diseases and PV				
Perceived Susceptibility Scale	1.26 (1.05, 1.50)*	1.49 (1.17, 1.88)**	1.33 (1.08, 1.64)**	1.64 (1.22, 2.22) ***
Perceived Benefit for Oneself Scale	2.16 (1.72, 2.71)***	3.48 (2.41, 5.03)***	2.33 (1.76, 3.09) ***	3.22 (2.08, 4.97) ***
Perceived Benefit for Others Scale	2.60 (1.98, 3.40)***	3.06 (2.18, 4.29)***	2.57 (1.88, 3.50) ***	2.54 (1.79, 3.61) ***
Perceived Barrier Scale	0.38 (0.30, 0.49)***	0.36 (0.27, 0.48)***	0.28 (0.20, 4.04) ***	0.30 (0.20, 0.44) ***
Your significant others suggest you to take up PV				
Disagree/neutral	1.0	1.0	1.0	1.0
Agree	18.24 (7.81, 42.61)***	8.24 (3.09, 22.00)***	104.80 (13.34, 765.82) ***	79.58 (8.21, 540.48) ***
You are confident to take up PV if you want				
Disagree/neutral	1.0	1.0	1.0	1.0
Agree	10.42 (4.15, 26.14)***	15.92 (6.42, 39.46)***	26.37 (6.34, 109.68) ***	17.85 (4.16, 76.53)***
Peer influence related to PV				
Having at least one peer of similar age who had taken up PV				
No	1.0	1.0	1.0	1.0
Yes	13.30 (7.81, 22.64) ***	16.61 (8.14, 33.91) ***	9.43 (2.99. 23.78) ***	8.55 (2.91, 25.15) ***
Social media influence related to PV				
Social Media Influence Scale	1.49 (1.09, 2.03)*	1.83 (0.99, 3.40)†	1.17 (0.62, 2.24)	1.92 (0.80, 4.60)

OR: crude odds ratios.
AOR: odds ratios adjusted for significant background variables listed in Table 3.
†0.05 < p < 0.10, *P < 0.05, **P < 0.01, ***P < 0.001.

completing PV for all older adults, as associated factors of these two dependent variables were similar. Some insights focus on segmentation. According to the social marketing approaches, careful segmentation would improve the effectiveness of health promotion programs.[37] In our study, older age was positively associated with both dependent variables, which may be due to older participants perceiving a greater need to protect themselves by taking up vaccination, as Lau et al.'s study.[23] Future health promotion should pay more attention to those who are younger. Higher education level was also positively associated with both dependent variables. It is possible that those with higher education level can better understand health communication messages delivered by the governmental program. Given the relatively low education level among older adults in Hong Kong, [38] health communication messages should be made easy to understand and straightforward. Pilot testing of the health communication messages among older adults with low education is necessary for future programs. Living alone was found to be a barrier of receiving a single dose of PV but not PV completion. Systematic review suggested that living alone was associated with lower vaccination uptake among older adults.[39] Living alone is an indicator of social isolation which is associated with an increase in mortality.[40] With an increasing aging population, the number of older adults who are living alone may continue to rise in Hong Kong.[41] It is hence important to increase coverage of preventive measures such as PV among elderly who are living alone in future programs. Interestingly in our study, being married or cohabited with spouse was associated with lower uptake of the first dose of PV. This finding suggested that not living alone might also have different effects on PV uptake depending on household composition.Very few participants provided correct responses to questions assessing knowledge related to diseases caused by *Streptococcus pneumoniae* and PV. It is potentially useful to improve such knowledge, as the level of knowledge was positively associated with receiving a single dose of PV and PV completion. However, supplying knowledge alone is not enough to change vaccination behaviors.[42] Interventions need to change theory-based perception related to PV.

The HBM is a potentially useful framework to guide the development of future programs, as all its constructs were significantly associated with both dependent variables in expected directions. We should enhance their perceived susceptibility to PD/IPD as it was a facilitator. There is much room for improvement. It is also useful to increase the perceived benefits of PV, as it was a facilitator of PV completion. In addition to the beneficial effects of PV for oneself (e.g., prevent pneumonia and severe IPD), health communication messages in future programs should also emphasize that PV uptake would also result in herd immunization protecting individuals who are not immune to *Streptococcus pneumoniae*.[43] Previous studies showed that belief in herd immunity was a facilitator for having children vaccinated against measles, mumps, and rubella among parents.[44] Future programs should also remove barriers related to cost, side effects, and inconvenience. Under the current policy, elderly without any high-risk condition of IPD are not eligible to receive free PV in public health-care sectors.[5] They can only receive subsidized PV at enrolled private doctors. Policymakers should examine whether there is extra cost (e.g., consultation fee) for receiving PV at private doctors that may offset the subsidization provided by the government. Study about willingness to pay is also useful to inform the out-of-pocket payment for PV in future.[45] To remove the concern of side effects, health communication messages should emphasize the safety of PV. Positive experience shared by vaccinated peers is also useful. To remove the feeling of inconvenience, future programs should provide information about operating hours and the location of clinics providing PV near where the participants are living. Cue to action and perceived self-efficacy were both facilitators. Future programs should have significant others of older adults (e.g., family members, peers, and health professionals) to give reminders to take up PV in order to provide a strong cue to action. Facilitating older adults to form an action plan to complete PV is a potentially useful strategy to improve perceived self-efficacy.[46]

This study confirmed the significant influence of peers on PV uptake among older adults. The Social Learning Theory posits that observation of peers is a major source of influence on people's health attitudes and behaviors.[47] Given the high rapport and trust between elderly, older adults often perceive peers' experience and information to be credible.[28] Therefore, older adults who have been vaccinated for PV may play important roles as volunteers in future programs. They may influence others by disseminating health communications and sharing their positive experience related to PV.

Future programs should consider using social media as an additional channel to promote PV, as the association between social media exposure to PV-related information and PV completion was of marginal significant. In today's world, observation of peers may occur both online and offline.[48] Given the rapid increase in social media use among older adults in Hong Kong, [25] social media may have a greater influence on health behaviors in this population in future.

This study had the strength of being theory-based and was based on a random and population-based sample. However, it had some limitations. First of all, it was a limitation that this study did not include older residents of residential care homes. The finding may not be generalizable to the entire older adults in Hong Kong. Since we excluded a group of older adults with a high prevalence of PV uptake, [15] the prevalence of PV completion reported by this study was likely to be underestimated. Second, non-response may introduce selection bias. Our response rate was relatively high (63.4%) as compared to other random telephone surveys of similar topics.[23,24] We did not collect information of older adults who were excluded due to lack of effective communication with the interviewers. It is possible that some of these older adults had high-risk condition(s) of severe IPD. Selection bias might exist. Third, data were self-reported and verification was not feasible. Recall bias might exist. Fourth, items and scales were constructed for this study. Although these scales demonstrated good internal reliability, they were not externally validated. Moreover, causality could not be established as this was a cross-sectional study.

In sum, the prevalence of PV uptake and PV completion among community-living elderly in Hong Kong was very low. Health promotion is needed to increase PV uptake and completion. More attention should be given to those with high-risk conditions of severe IPD. Integrating PV with seasonal influenza vaccination, enhancing knowledge, modifying perceptions, and making use of senior volunteers may be potentially useful strategies to promote PV among community-living elderly in Hong Kong.

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No potential conflicts of interest were disclosed.

Contributor

Author ZW, JTFL, and MI designed the study and wrote the protocol. Author ZW designed the questionnaire and analytical plan. Author ZW and ML supervised the data collection process. Author ZW and FY analyzed and interpreted the data and wrote the manuscript. Author ZW revised the manuscript critically and finalized the paper. All authors contributed to and approved the final manuscript.

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