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Factors associated with influenza vaccine uptake in older adults living in the community in Singapore

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SUMMARY

In Singapore, influenza vaccination is recommended for persons at higher risk of complications of seasonal influenza, including those with chronic medical conditions and the elderly (individuals aged ⩾65 years). We investigated the factors associated with influenza vaccine uptake based on a nationally representative sample of community-dwelling adults aged ⩾50 years. The data for this study were obtained from the National Health Surveillance Survey (NHSS) 2013. The association between influenza vaccine uptake and socio-demographic and health-related variables was analysed using univariable and multivariable logistic regression models. Of 3700 respondents aged ⩾50 years in the NHSS, 15·2% had received seasonal influenza vaccination in the past year. Older age, single marital status and economic inactivity were the socio-demographic variables independently associated with vaccine uptake. Health-related factors which were predictive of influenza vaccine uptake were sufficient total physical activity, better self-rated health, having at least one medical condition at risk of influenza complications and a regular family doctor/general practitioner. Influenza vaccine uptake in community-dwelling older adults was low. Our findings are of relevance in the formulation of public health policies and targeted health promotion strategies to increase vaccine uptake in this population group.

Key words: At-risk population, coverage, elderly, vaccination.

INTRODUCTION

The disease burden of influenza virus infection is of significant public health importance worldwide as it results in excess influenza-associated morbidity, hospitalizations and deaths [1]. The cornerstone for the reduction of adverse health outcomes arising from influenza virus infection is annual influenza vaccination as it is a safe, inexpensive and effective preventive strategy [2].

In Singapore, annual influenza vaccination is recommended by the Ministry of Health (MOH) Expert Committee on Immunization (ECI) to protect population groups at higher risk of influenza complications, which include the elderly (i.e. those aged ⩾65 years), and persons with chronic medical conditions such as diabetes, asthma and heart disease [3].

A study has shown that the age-specific influenza-associated hospitalization rate for pneumonia and

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influenza (P&I) in Singapore during 2004–2008 and 2010–2012 followed a J-shaped pattern, which alluded to the considerable disease burden of influenza in older adults in Singapore, a country with a rapidly ageing population [4]. Based on the Health Behaviour Surveillance of Singapore conducted by the Health Promotion Board (HPB) via telephone and face-to-face with selected Singapore residents aged 18–69 years, the proportion of Singaporeans who reported having been vaccinated against influenza in the last 12 months was low at 11·2% in 2012 [4].

In view of its uniqueness and lack of clear climatic seasons, the spread of influenza in the tropics differs from that of temperate regions [5, 6]. A bimodal pattern of influenza activity is observed in tropical Singapore with two periods of higher influenza activity in the beginning and middle of the year coinciding with the Northern and Southern Hemisphere winter seasons, respectively [7]. In a study to identify the most appropriate time for vaccination based on influenza surveillance data from 10 countries in tropical and subtropical parts of southern and south-eastern Asia, it was determined that there was no ideal vaccination timing for equatorial countries with year-round influenza activity and without defined peaks of disease activity [8]. HPB recommends vaccination before the peak of the influenza season which is generally from December to February, and May to July in Singapore [9].

Population-based surveys to determine the uptake of seasonal influenza vaccine can provide important information on the progress of national vaccination programmes and level of awareness in the general population [10]. The aim of our study was to estimate the seasonal influenza vaccine uptake in the older Singapore resident population living in the community, and investigate socio-demographic and health-related factors associated with uptake of seasonal influenza vaccine based on data obtained from the National Health Surveillance Survey (NHSS) 2013.

MATERIALS AND METHODS

Study participants

The cross-sectional NHSS 2013 was commissioned by MOH, Singapore. This was the third in the survey series conducted every 6 years since 2001 [11]. The primary aim of the NHSS was to assess the health status of the community-dwelling Singapore resident population (Singapore citizens and permanent residents), as part of MOH's nationwide surveillance of non-communicable diseases and their behavioural risk factors. The survey fieldwork was conducted between November 2012 and October 2013.

A two-stage stratified sampling was performed on a database set containing all dwellings in Singapore, and the Kish grid selection method was used to identify a respondent from each selected household address. Of the 18 000 households selected with 16 211 eligible Singapore residents, 9631 individuals aged $\geqslant$18 years participated in the survey, giving a response rate of 59·4% in the primary sample of adults. The overall sample weights were the product of sample weights for the households and selected household members. Informed consent was obtained from the survey respondents. Ethical approval for NHSS 2013 was given by the Institutional Review Board Ethics Committee of HPB, Singapore.

The main outcome as a dependent variable in our study was the answer to the question posed to respondents aged $\geqslant$50 years in NHSS 2013: 'Have you ever had influenza (flu) vaccination in the past year?' After excluding 17 participants who answered 'Don't know/not sure' from the data analysis, the final sample for our study consisted of 3700 older adults aged $\geqslant$50 years.

Characteristics investigated for possible association with seasonal influenza vaccine uptake included potential confounders and factors amenable to public health action. The following demographic characteristics were studied: age in two groups (50–64 years, $\geqslant$65 years), gender, ethnic group (Chinese, Malay, Indian, Other), and marital status (never married, married, separated/divorced/widowed). Educational level and monthly average household income were used as indicators for socioeconomic status (SES). In terms of work status, those who were working in the last 12 months were considered as economically active, while students, national servicemen, homemakers/housewives, retirees and those who were unemployed were deemed as economically inactive.

The following health-related characteristics deemed to be modifiable were also examined: body mass index, smoking status, alcohol status, total physical activity (TPA) and self-rated health. The recommendation for sufficient TPA is at least 150 min of moderate intensity activity per week or at least 60 min of vigorous intensity activity per week, or equivalent. The presence of self-reported chronic medical conditions at risk of influenza-related complications was

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determined by asking the respondents if they were ever diagnosed by a doctor (western trained) with any of the following: diabetes mellitus, heart problem (chest pain and/or heart attack), stroke, renal disease, asthma and/or chronic obstructive pulmonary disease [12]. In terms of health services utilization practices, respondents were asked: 'Do you have a regular family doctor/general practitioner (GP) whom you will consult when you have a health problem?'

Statistical analysis

The main outcome of uptake of seasonal influenza vaccination in the past year was a binary variable (yes/no). The χ^2 test or Fisher's exact test, where appropriate, was used to test for group differences. Crude odds ratios (OR) and adjusted odds ratios (aOR) with their 95% confidence intervals (CI) were estimated using univariable and multivariable logistic regression models. Multivariable logistic regression was used to determine independent factors associated with influenza vaccination, using forward stepwise selection based on maximum partial likelihood estimation with $P < 0{\cdot}20$ for entry of variables and $P < 0{\cdot}05$ for removal of variables. Initial candidate variables were those with $P < 0{\cdot}20$ in the univariable logistic regression analyses. All P values reported were two-sided and statistical significance was taken as $P < 0{\cdot}05$. All statistical analyses were performed using SPSS v. 22 (IBM Corp., USA).

RESULTS

In 2013, about 15·2% of older adults aged ⩾50 years had received seasonal influenza vaccination in the past year. Table 1 shows the distribution of socio-demographic and health-related characteristics according to their reported influenza vaccination status in the past year. There were significant differences between these two groups by gender, ethnic group, marital status, work status, TPA, self-rated health, and whether they had a regular doctor/GP for consultation. Compared to older adults who had not been vaccinated against influenza in the past year, a significantly higher proportion of those who had received seasonal influenza vaccination were women, of 'Other' ethnicity, never married, were economically inactive, had sufficient TPA, good/very good self-rated health and a regular family doctor/GP to consult for health problems. The proportion of older adults vaccinated against influenza who were Chinese, married, and self-rated their health as bad/very bad was significantly lower than in those who had not been vaccinated.

Table 2 shows the proportion of vaccine uptake according to socio-demographic and health-related factors. A J-shaped pattern was observed between monthly average household income and vaccination coverage. Stepwise increment in both monthly average household income (for three tiers: S$2000–<4000, S$4000–<6000, and ⩾S$6000) and better self-rated health corresponded to an increase in proportion of vaccine uptake.

Univariable logistic regression analyses suggest that women, those of 'Other' ethnicity, never married, economically inactive, having sufficient TPA, good/very good self-rated health and a regular family doctor/GP to consult for health problems were at significantly higher odds of uptake of seasonal influenza vaccination (Table 2).

In the multivariable regression model, independent factors significantly associated with self-reported influenza vaccination were age group, ethnic group, marital status, monthly average household income, work status, TPA, self-rated health, whether there were any self-reported medical conditions at risk of influenza-related complications and whether there was a regular doctor/GP (Table 2). Compared to the 50–64 years age group those aged ⩾65 years were more likely to be vaccinated against seasonal influenza (aOR 1·30, 95% CI 1·02–1·67) (Table 2). There was no significant difference in the likelihood of being vaccinated in the three main ethnic groups (Chinese, Malay, Indian). While 'Other' ethnicity was significantly associated with a higher likelihood of vaccine uptake (aOR 2·85, 95% CI 1·65–4·91) compared to the Chinese, there were only 64 older adults whose ethnic group was 'Other', comprising only 1·7% of all respondents. In view of the small number of older adults of 'Other' ethnicity, the result warrants careful interpretation (Table 1). Compared to those who were never married, married adults had a lower likelihood of having received influenza vaccination in the past year (aOR 0·61, 95% CI 0·44–0·86). Compared to older adults with an average monthly household income of <S$2000, those with household income of ⩾S$6000 were more likely to be vaccinated against influenza (aOR 0·61, 95% CI 1·17–2·17). Being economically active was significantly associated with lower vaccine uptake (aOR 0·72, 95% CI 0·59–0·89). In terms of modifiable lifestyle risk factors, those with sufficient TPA were more likely to be vaccinated against influenza (aOR 3·04, 95% CI 2·38–3·90). A trend of decreasing

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Table 1. *Distribution (%) of socio-demographic and health-related characteristics in a representative sample of older community-dwelling adults aged ⩾50 years according to reported influenza vaccination status in the past year, Singapore, 2013*

	Vaccination status		
	Yes ($N = 564$) *n* (%)	No ($N = 3136$) *n* (%)	Total ($N = 3700$) *n* (%)
Age group (years)			
50–64	388 (68·8)	2274 (72·5)	2662 (71·9)
⩾65	176 (31·2)	862 (27·5)	1038 (28·1)
Gender			
Male	249 (44·1)	1538 (49·0)	1787 (48·3)
Female	315 (55·9)	1598 (51·0)	1913 (51·7)
Ethnic group			
Chinese	439 (77·8)	2556 (81·5)	2995 (81·0)
Malay	58 (10·3)	341 (10·9)	399 (10·8)
Indian	45 (8·0)	197 (6·3)	242 (6·5)
Other	22 (3·9)	42 (1·3)	64 (1·7)
Marital status			
Never married	52 (9·2)	212 (6·7)	264 (7·1)
Married	413 (73·2)	2428 (77·4)	2841 (76·8)
Separated/divorced/widowed	99 (17·6)	496 (15·8)	595 (16·1)
Education level			
No formal/primary/PSLE	235 (41·7)	1158 (36·9)	1393 (37·7)
Secondary/O-level	204 (36·2)	1237 (39·4)	1441 (38·9)
A-level/diploma/degree	125 (22·2)	741 (23·6)	866 (23·4)
Monthly household income (S$)			
<2000	113 (19·9)	619 (19·7)	732 (19·8)
2000–<4000	93 (16·5)	596 (19·0)	689 (18·6)
4000–<6000	67 (11·9)	404 (12·9)	471 (12·7)
⩾6000	134 (23·8)	636 (20·3)	770 (20·8)
Refused/don't know	157 (27·9)	881 (28·1)	1038 (28·1)
Work status			
Economically inactive	324 (57·4)	1618 (51·6)	1942 (52·5)
Economically active	240 (42·6)	1518 (48·4)	1758 (47·5)
Body mass index (kg/m^2)*			
<18·5 (underweight)	26 (4·6)	198 (6·3)	224 (6·1)
18·5 to <25 (normal weight)	342 (60·6)	1776 (56·6)	2118 (57·2)
25 to <30 (overweight)	156 (27·7)	939 (29·9)	1095 (29·6)
⩾30 (obese)	40 (7·1)	223 (7·1)	263 (7·1)
Sufficient total physical activity†			
No	87 (15·4)	1101 (35·1)	1188 (32·1)
Yes	477 (84·6)	2035 (64·9)	2512 (67·9)
Current smoking‡			
No	501 (88·8)	2782 (88·7)	3283 (88·7)
Yes	63 (11·2)	354 (11·3)	417 (11·3)
Current drinking§			
No	440 (78·0)	2474 (78·9)	2914 (78·8)
Yes	124 (22·0)	662 (21·1)	786 (21·2)
Self-rated health			
Good or very good	375 (66·5)	1832 (58·4)	2207 (59·6)
Moderate	183 (32·4)	1149 (36·6)	1332 (36·0)
Bad or very bad	6 (1·1)	155 (4·9)	161 (4·4)
Presence of self-reported medical conditions at risk of influenza-related complications			
No	427 (75·7)	2454 (78·3)	2881 (77·9)
Yes	137 (24·3)	682 (21·7)	819 (22·1)

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Table 1 (*cont.*)

	Vaccination status		
	Yes ($N = 564$) *n* (%)	No ($N = 3136$) *n* (%)	Total ($N = 3700$) *n* (%)
Regular family doctor/GP			
No	312 (55·3)	1899 (60·6)	2211 (59·8)
Yes	252 (44·7)	1237 (39·4)	1489 (40·2)

PSLE, Primary School Leaving Examination.
* Based on the WHO international classification of weight status and abdominal fatness.
† Physical activity participation in all three domains – at work (paid or unpaid work including household chores), walking while travelling to and from places and leisure-time physical activity – was assessed using the Global Physical Activity Questionnaire developed by the WHO. Total physical activity is classified according to three levels: low, moderate and high.
‡ Current smokers are defined as those who report daily or occasional smoking and have ever smoked at least 100 cigarettes (lifetime).
§ Current drinkers are defined as those who report drinking regularly, frequently or occasionally and have consumed alcohol within the past 12 months.

likelihood of being vaccinated with poorer self-rated health was observed; those with poorer self-rated health were less likely to be vaccinated against influenza. Older adults who reported at least one doctor-diagnosed medical condition at risk of influenza-related complications were more likely to report influenza vaccination (aOR 1·43, 95% CI 1·14–1·80). The likelihood of vaccine uptake was significantly higher in older adults who had a regular family doctor/GP to consult when they had a health problem (aOR 1·28, 95% CI 1·06–1·55).

Figure 1 shows that the proportion of vaccine uptake generally increased with increasing age. The vaccination coverage increased from 14·1% in older adults aged 50–54 years to 16·4% in those aged 65–69 years, followed by a non-significant decrease to 13·4% in the 70–74 years age group. Older adults aged $\geqslant 80$ years had the highest proportion of vaccine uptake at 22·4%.

Figure 2 shows that the proportion of vaccine uptake was higher in the group having at least one self-reported medical condition at risk of influenza-related complications in the 50–64 and $\geqslant 75$ years age groups compared to those with no chronic medical conditions at risk of influenza-related complications. The differences in age-specific proportions between these two groups were not statistically significant (all $P > 0·05$).

DISCUSSION

Our study revealed that older age, single marital status, higher monthly average household income and economic inactivity were the socio-demographic variables independently associated with influenza vaccine uptake. Health-related variables which were predictive of influenza vaccine uptake were sufficient TPA, good/very good self-rated health, having at least one medical condition at risk of influenza complications and a regular family doctor/GP.

Compared to individuals aged 50–64 years, those aged $\geqslant 65$ years were more likely to get vaccinated against seasonal influenza. The finding could be explained by the fact that one of the population groups recommended for vaccination by the ECI is the elderly (i.e. aged $\geqslant 65$ years). Hence, there may be heightened awareness in these individuals and/or their family members and healthcare providers including family doctors/GPs of the imperative to get this age group protected against adverse influenza-related events. However, as the proportion vaccinated against seasonal influenza was <20% in these two age groups, more efforts would be required to increase their vaccination uptake in the community. In Singapore, since 1 January 2014, in order to further raise awareness and increase influenza vaccine uptake, individuals at higher risk of developing influenza-related complications are allowed to use Medisave, a compulsory national healthcare savings scheme, to pay for influenza vaccination in the outpatient setting [3]. In response to calls by the World Health Organization (WHO) Global Agenda on Influenza to measure the progress of national influenza vaccination programmes, the Macro-epidemiology of Influenza Vaccination Study Group gathered information on influenza vaccination in 56 countries for the period 1997–2003, and found that in many instances, higher uptake appeared to be associated with public

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Table 2. *Association between influenza vaccination in the past year and socio-demographic and health-related characteristics in a representative sample of older community-dwelling adults aged ⩾50 years, Singapore, 2013*

		Univariable model			Multivariable model*		
	% vaccinated	cOR	(95% CI)	*P* value	aOR	(95% CI)	*P* value
Age group (years)				0·069			0·036
50–64	14·6	1·00	Referent		1·00	Referent	
⩾65	17·0	1·20	(0·99–1·46)		1·30	(1·02–1·67)	
Gender				0·032			
Male	13·9	1·00	Referent				
Female	16·5	1·22	(1·02–1·46)				
Ethnic group				<0·0005			0·001
Chinese	14·7	1·00	Referent		1·00	Referent	
Malay	14·5	0·98	(0·73–1·32)	0·907	1·00	(0·73–1·35)	0·974
Indian	18·6	1·34	(0·96–1·88)	0·091	1·30	(0·91–1·85)	0·146
Other	34·4	3·04	(1·80–5·13)	<0·0005	2·85	(1·65–4·91)	<0·0005
Marital status				0·043			0·004
Never married	19·7	1·00	Referent		1·00	Referent	
Married	14·5	0·69	(0·50–0·95)	0·022	0·61	(0·44–0·86)	0·005
Separated/divorced/widowed	16·6	0·81	(0·56–1·17)	0·260	0·84	(0·56–1·25)	0·394
Educational level				0·118			
No formal/primary/PSLE	16·9	1·00	Referent				
Secondary/O-level	14·2	0·82	(0·67–1·00)	0·054			
A-level/diploma/degree	14·4	0·84	(0·66–1·06)	0·142			
Monthly household income (S$)				0·305			0·011
<2000	15·3	1·00	Referent		1·00	Referent	
2000–<4000	13·5	0·86	(0·64–1·16)	0·329	0·99	(0·72–1·35)	0·928
4000–< 6000	14·2	0·92	(0·67–1·28)	0·634	1·10	(0·78–1·57)	0·588
⩾6000	17·4	1·17	(0·89–1·54)	0·266	1·59	(1·17–2·17)	0·003
Refused/don't know	15·1	0·99	(0·76–1·29)	0·930	1·09	(0·83–1·44)	0·536
Work status				0·012			0·002
Economically inactive	16·7	1·00	Referent		1·00	Referent	
Economically active	13·7	0·79	(0·66–0·95)		0·72	(0·59–0·89)	
Body mass index				0·207			
<18·5 (underweight)	11·6	1·00	Referent				
18·5 to <25 (normal weight)	16·1	1·48	(0·97–2·26)	0·072			
25 to <30 (overweight)	14·2	1·28	(0·82–1·99)	0·284			
⩾30 (obese)	15·2	1·38	(0·81–2·34)	0·235			
Current smoking				0·967			
No	15·3	1·00	Referent				
Yes	15·1	0·99	(0·75–1·32)				

Table 2 (*cont.*)

		Univariable model			Multivariable model*		
	% vaccinated	cOR	(95% CI)	*P* value	aOR	(95% CI)	*P* value
Current drinking				0·667			
No	15·1	1·00	Referent				
Yes	15·8	1·05	(0·84–1·30)				
Sufficient total physical activity				<0·0005			<0·0005
No	7·3	1·00	Referent		1·00	Referent	
Yes	19·0	2·95	(2·32–3·75)		3·04	(2·38–3·90)	
Self-rated health				<0·0005			<0·0005
Good or very good	17·0	1·00	Referent		1·00	Referent	
Moderate	13·7	0·78	(0·64–0·95)	0·011	0·68	(0·55–0·83)	<0·0005
Bad or very bad	3·7	0·19	(0·09–0·44)	<0·0005	0·17	(0·07–0·40)	<0·0005
Presence of self-reported medical conditions at risk of influenza complications				0·182			0·002
No	14·5	1·00	Referent		1·00	Referent	
Yes	15·8	1·15	(0·94–1·42)		1·43	(1·14–1·80)	
Regular family doctor/GP				0·022			0·012
No	16·9	1·00	Referent		1·00	Referent	
Yes	14·1	1·24	(1·03–1·48)		1·28	(1·06–1·55)	

cOR, Crude odds ratio; aOR, adjusted odds ratio; CI, confidence interval; PSLE; GP, general practitioner.

* Adjusted for age group, ethnic group, marital status, monthly household income, work status, total physical activity, self-rated health, whether there were any self-reported medical conditions at risk of influenza-related complications and whether there was a regular doctor/GP.

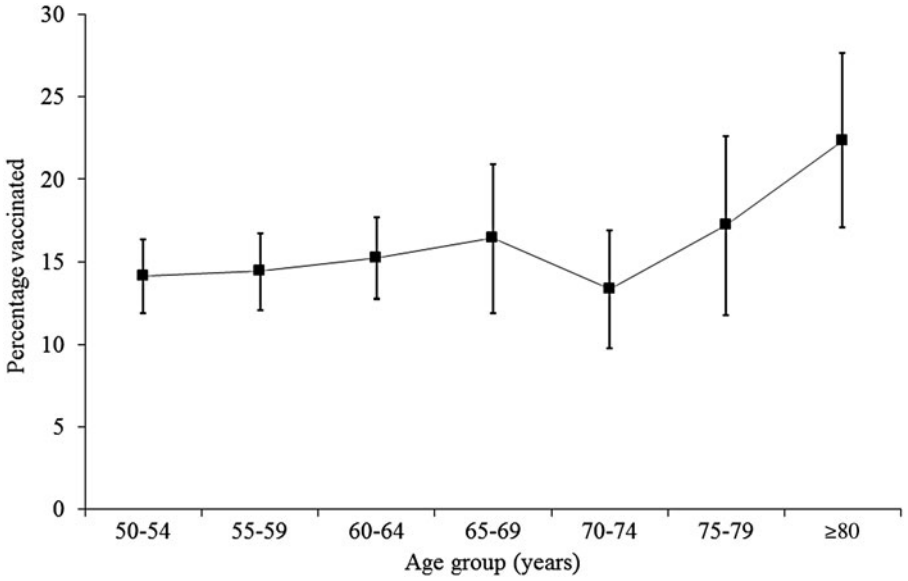

Fig. 1. Proportion (%) vaccinated against influenza in the past year by age group, Singapore, 2013. The vertical lines indicate 95% confidence intervals.

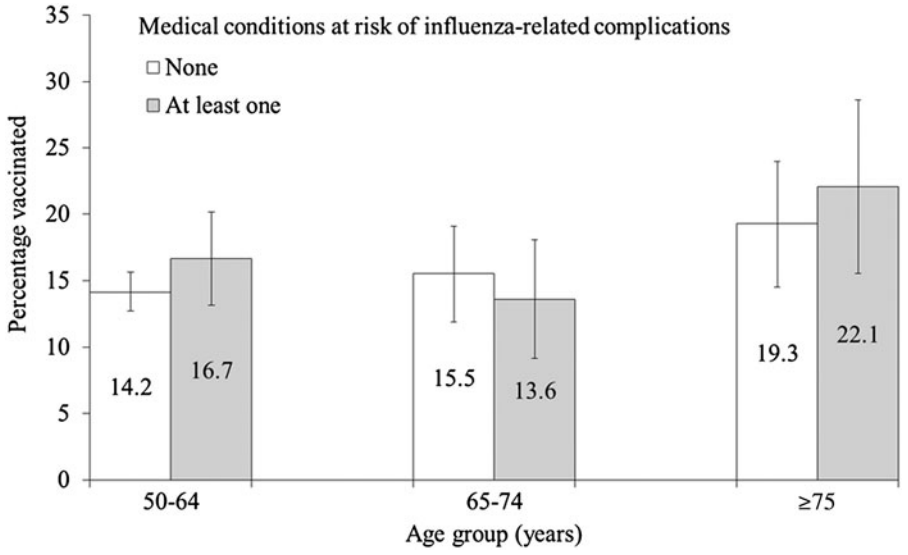

Fig. 2. Proportion (%) vaccinated against influenza in the past year by age group and presence of self-reported medical conditions at risk of influenza complications, Singapore, 2013. The vertical lines indicate 95% confidence intervals.

reimbursement for vaccination [13]. Results from a survey conducted during 2005–2006 in 10 countries in Africa, Asia Pacific, Eastern Europe, Latin America and the Middle East also indicated that fully funded immunization programmes together with high awareness in the population are important factors to attain high influenza vaccination coverage [10]. In the United States, having healthcare coverage was found to be the strongest independent predictor of influenza vaccination in adults aged 18–64 years and the elderly aged $\geqslant$65 years [14].

Being married was found to be an independent factor associated with lower likelihood of vaccine uptake. This differed from the findings of some studies such as one in South Korea in older adults aged $\geqslant$50 years in 2010–2011 where individuals who were single tended not to get vaccinated compared to those who were married [15]. In a cross-sectional study conducted in Italy in

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1999–2000, being married was negatively associated with vaccine uptake in the 45–64 years age group, whereas a positive association was found in the elderly aged 65–89 years [16]. On the other hand, in a cross-sectional survey of Chinese elderly persons aged ⩾65 years in Hong Kong, single marital status was significantly associated with higher vaccine uptake [17].

Findings of the association of SES with vaccine uptake were not consistent. In our study, average monthly household income was significantly associated with uptake of influenza vaccine while educational level was not an independent significant factor. However, a caveat to take into consideration in the interpretation of the association was that 28·1% of the older adults either did not know their average monthly household income or refused to provide an answer (Table 1). In the South Korean study, the level of education and household income were not significantly associated with influenza vaccine uptake in the multivariable regression model for adults aged ⩾50 years [15]. A study in the United States found that lower educational level and lower annual household income were both significantly associated with a lower vaccine uptake rate [14]. This was contrary to the finding of another US study which showed that older adults aged ⩾50 years with lower annual household incomes were more likely to get vaccinated than those with higher incomes [18]. In an observational study of frail and old people living in the community in 11 European countries, lower SES was associated with lower influenza vaccination coverage [19]. The financing policy for the uptake of seasonal influenza vaccine was deemed to be a determinant in vaccination coverage associated with SES in the South Korean study [15]. Requiring self-financing or co-payment for vaccination could discourage the uptake of vaccine, as seen in South Korea during the 2009–2010 influenza A(H1N1)pdm09 season [20]. In a study on Australian elderly, it was postulated that the non-significant association between SES (education and income) and vaccine uptake was due to the fact that universal funding of influenza vaccination is restricted to those aged ⩾65 years [21]. Free vaccinations are provided to the elderly in several countries, such as the United States through the Medicare programme [14], Italy through the National Health Service programme [16], and Taiwan through the National Health Insurance programme [22]. The findings on the association of SES with influenza vaccination would have to be considered in the context of financing policy.

Economic inactivity was an independent factor significantly associated with influenza vaccine uptake in older adults, which could serve as a crude indicator of their state of health in terms of the ability to work as well as personal financial status.

Having sufficient TPA was a factor for reporting influenza vaccination. Those who lead a healthy lifestyle may be more inclined to protect their health and adopt preventive measures such as vaccination against seasonal influenza. In a population-based national cohort study of community-dwelling Canadian elderly individuals aged ⩾65 years conducted in 1991, regular exercise was found to be a factor predictive of influenza vaccination [23]. In the US study, physically active elderly were also more likely to receive influenza vaccine [14].

Our study shows that older adults who self-rated their health as moderate and bad or very bad were less likely to get vaccinated than those with a good or very good self-rating. Those with better self-rated health may have a more positive attitude towards preventive health services and/or higher level of awareness or knowledge about health-related services, and are more inclined to maintain their physical well-being. As only 4·4% of the older adults had bad or very bad self-rated health, it may be considered a minor factor associated with influenza vaccination (Table 1). Our findings were different from those of several other studies in which individuals with poor self-reported health were more likely to get vaccinated, such as a study in South Korea in older adults aged ⩾50 years [15], and another study in Italy in individuals aged 45–64 years and 65–89 years [16]. This could be due to differences in settings and assessment of self-rated health.

Self-report of medical conditions at risk of influenza complications was significantly associated with vaccine uptake, which was consistent with that of several other studies, including South Korea [15], Italy [16] and Taiwan [22]. Older adults with chronic medical conditions may perceive themselves to be at a higher risk of influenza complications, and hence the motivation to seek protection via vaccination. Their caregivers, family doctors/GPs and other healthcare professionals are also more likely to encourage influenza vaccination for this at-risk group, in accordance to the recommendation by the ECI. As individuals at higher risk of developing influenza-related complications have been allowed to use Medisave since 2014, the vaccine coverage in this group could have increased after our study which was based on survey data collected in 2013.

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Our study revealed that older adults who had a regular family doctor/GP to consult for their health problems tended to get vaccinated. This was an important factor which could have a large impact on influenza vaccine uptake. As family physicians are the primary point of contact for community-dwelling older adults, they play an important role in recommending their patients to go for vaccination. Engaging family physicians to promote vaccination would serve as an effective approach to protect individuals, particularly those with chronic medical conditions, against complications of influenza virus infection. In Finland, the importance of the advice rendered by GPs *vis-à-vis* at-risk population groups was supported by the findings from a study comparing the impact of vaccination strategy and methods of information on influenza and pneumococcal vaccination coverage in the elderly from 1992 to 1994 [24]. Two studies involving household surveys, one in five European countries [25] and another in Great Britain [26] found that the family doctor was the key driver for uptake of influenza vaccination.

In Singapore, MOH issues circulars to healthcare institutions and medical practitioners once or twice a year when new seasonal influenza vaccines with a change in formulation are released [8]. HPB and healthcare providers have been putting consistent efforts to educate the public on the importance of influenza vaccinations [27]. In recent years, public acute-care hospitals have started programmes to increase vaccine uptake in adult patients, including vaccination against influenza, such as a pre-discharge vaccination programme adopted by Tan Tock Seng Hospital (TTSH) for all its patients in 2010 [28, 29]. In November 2015, staff from TTSH under the National Healthcare Group, one of the regional health systems in Singapore, started visiting senior activity centres to administer free influenza and pneumococcal vaccinations ahead of the peak in influenza activity [30]. As our finding of 15·2% vaccinated against seasonal influenza in older adults aged $\geqslant$50 years was based on NHSS conducted in 2013, the implementation of these programmes and other initiatives could lead to higher vaccine uptake rate in the community thereafter.

Our study indicated the need to increase influenza vaccine uptake in older adults. The influenza vaccination coverage was 14·6% in the 50–64 years age group and 17·0% in the $\geq$65 years age group in 2013. In a survey, the influenza vaccine uptake in the elderly in 20 European countries ranged from 1·8% in Lithuania to 82·1% in The Netherlands [31]. Most of the coverage levels fell short of the 75% target set by the WHO for the elderly population by 2010 [32, 33].

In Singapore, the question on influenza vaccine uptake was included for the first time in NHSS 2013. This survey provided a large and nationally representative sample of community-dwelling older adults that had enabled us to examine socio-demographic and health-related factors associated with seasonal influenza vaccine uptake. Based on a systematic review, age, health conditions and recommendations by physicians were found to be the strongest predicting factors for influenza and pneumococcal vaccination in elderly people [34]. These three factors were in the significant independent factors of seasonal influenza vaccine uptake in our study.

There are a few limitations to our study. We used self-report to ascertain influenza vaccine uptake and health-related variables including doctor-diagnosed medical conditions, instead of vaccination and medical records. Thus, there may be mis-classification due to recall bias. Nevertheless, self-report has been found to be a highly accurate way of assessing vaccination status in the elderly [35–38]. Given the cross-sectional design of NHSS 2013, we could only determine epidemiological associations rather than cause–effect relationships. As the survey was not designed to investigate the determinants of influenza vaccination, not all potential confounding factors could be included in our study.

Individuals who are less inclined to get vaccinated need to be cognisant of the risk of influenza complications, especially for the high-risk groups. Although there have been concerns about the reduced vaccine effectiveness in elderly persons aged $\geqslant$65 years compared to younger adults, the WHO has maintained that vaccination is still the most effective public health tool currently available to protect this age group against influenza [39]. In Singapore, before the vaccination drive in November 2015, doctors from TTSH who worked with staff at various senior activity centres to raise awareness on the importance of vaccination found that the elderly had some misconceptions, such as vaccinations were unsafe for them if they had chronic medical conditions or a previous serious illness such as cancer, and influenza vaccine was not effective as it did not prevent them from becoming sick [30]. In our study, information on drivers and barriers of influenza vaccination in older adults was not available, as questions on knowledge, beliefs and awareness of the importance of seasonal influenza vaccination as well as frequency of influenza vaccination were not asked in NHSS 2013.

Although questions on self-reported doctor-diagnosed medical conditions at risk of influenza complication were included in the survey, the list was not comprehensive and other chronic conditions such as cancer and immunological disorders were not included. In addition, it was not captured in the survey questionnaire whether or not health-related decisions including vaccinations for older adults aged $\geqslant 50$ years were made by the respondents themselves or their children/caregivers.

Our study identified the socio-demographic and health-related factors which were independently associated with seasonal influenza vaccine uptake. These findings are of relevance in tailoring public health strategies and programmes to improve influenza vaccine coverage in older adults, particularly in those who are less likely to get vaccinated.

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DECLARATION OF INTEREST

None.

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