

RESEARCH PAPER



The estimated age-group specific influenza vaccine coverage rates in Hong Kong and the impact of the school outreach vaccination program

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ABSTRACT

Previous studies have shown that seasonal influenza strikes annually causing millions to fall sick and several hundred thousand to die globally. Hence, universal vaccination is a public health aim to control influenza. The Hong Kong Government started to introduce the School Outreach Vaccination (SOV) program in 2018 to increase vaccination rates in children. This study looked at the impact this had on hospital admissions and estimated vaccination rates in the total population, using a questionnaire-based tool. The SOV program significantly increased vaccination coverage rates with a 1% increase associated with a reduction of 4.3 influenza-related hospital admissions of school-aged children. The estimation of vaccine coverage rates among the under 5-year olds (48.5%), primary school children (69.3%) and over 65-year olds (45.7%), through the questionnaire-based tool, was within the 95% confidence interval of the coverage rates published by the Center for Health Protection of the Hong Kong Government, 47.4%, 68.1% and 45.8%, respectively. Extension of the SOV program should be considered in secondary schools to increase the coverage rates in adolescents. The questionnaire survey may inform government how to achieve universal vaccination for specific age groups.

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Introduction

Seasonal influenza strikes annually during the fall to early spring,^{1,2} resulting in a global outbreak affecting 5–10% of adults and 20–30% of children.³ The Centers for Disease Control and Prevention (CDC) estimated that 35.5 million illnesses, 16.5 million medical visits, and 34,200 deaths in the United States during 2018–2019 were related to influenza.⁴ Therefore, seasonal influenza is a tremendous public health concern that ideally requires universal vaccination of the total population. School populations are accessible for universal vaccination with school-based vaccination programs. A study conducted in Oakland has shown that school-located influenza vaccination sites have 7%–11% higher influenza vaccination coverage than the comparison sites, with the program associated with lower influenza hospitalization rates, a reduction of 36% and reduced illness-specific school absenteeism, the mean absences per 100 school days decreased from 2.84 days to 2.81 days,⁵ these results were also replicated in Japan.⁶ With teachers and school nurses playing an essential role in educating students and their parents about the rationale, safety, and effectiveness of vaccination, school outreach vaccination programs can not only reach broad and diverse populations, and give easier access to vaccines, but they can also engage children and parents who may have previously refused vaccination.^{7,8}

In Hong Kong, the government provides a free seasonal influenza vaccination to all students of primary schools participating in the school outreach vaccination (SOV) program,⁹ which is a voluntary program that covers all primary schools,

regardless of whether the students have Hong Kong resident status in order to increase influenza vaccine coverage rate among children.

A previous study in 2019 demonstrated the impact of the SOV program in increasing the vaccination rate of students in the SOV offering schools by 34.9% compared to the control schools.¹⁰ This current study aims to demonstrate the sustained impact of the SOV program as well as develop a tool that can estimate the total population's influenza vaccine coverage rate across different age groups, which is a key piece of information for public health policy decision-makers.

With the Covid-19 pandemic still rampant globally, studies have demonstrated that influenza vaccination might protect subjects from COVID-19's adverse impact.^{11,12} One study showed that a higher influenza vaccine coverage rate may reduce the spread and clinical consequence of COVID-19.¹¹ To mitigate the severity of COVID-19, many countries are doing their best to vaccinate their population with the COVID-19 vaccine, but challenges regarding vaccine availability and implementation remain huge for most nations.¹³ A simultaneous drive for both influenza and COVID-19 vaccinations in the coming winter and spring may synergistically reduce morbidity and mortality. This method to estimate the age specific influenza vaccine coverage rates could be utilized in the modeling of how the extent of influenza vaccine coverage interacts with COVID-19 vaccine coverage at a population level and the benefits of SOV in the implementation of universal vaccine administration.

Methodology

School information was collected from the Hong Kong Education Bureau website¹⁴ and 306 Hong Kong primary schools were contacted. Seventeen schools from 14 districts, including three special schools ensured 2379 subjects were successfully recruited randomly for this study in 2019. At that time, a questionnaire was developed to measure influenza vaccination coverage and influenza-like symptoms of the students. In 2020 further information surrounding household members and their vaccination rate was included in addition to the data surrounding student vaccination rate¹⁰ (Appendix A). Using the information about household members and their age, the vaccination coverage for the total Hong Kong population across different age groups can be estimated using the census data.¹⁵ Three schools requested e-questionnaires, and 14 schools conducted paper-based questionnaires which were sent to schools on 3rd January 2020 and collected in the middle of June 2020.

The survey results containing the child's and household member's influenza vaccination rates was compared with that of the previous study in 2019 using the Chi-square test.¹⁰ An estimation of the mean value and 95% confidence limit of the vaccination rates among the different age groups was also done. The influenza vaccination rates for specific age groups who are in the Government universal vaccination program over the three years (2017/18, 2018/19, and 2019/20) were retrieved from the website of the Center for Health Protection (CHP) of the Department of Health (DH) and compared with the estimated influenza vaccination rates.¹⁶

Influenza hospital admission data from September 2016 to August 2020 for children aged <12 years old with HKID and admitted with the first or second diagnostic ICD-9 coding of 487 (Influenza) were extracted from the HA electronic database. This data was split into two groups, those under 6 years of age on admission day and those greater than 6. A line chart of weekly influenza hospital admissions was plotted and used to present the influenza-related admission pattern from September 2016 to August 2020 (Figure 1). General observations were made from the figure and aligned with vaccination rate data. The effect of the increased vaccination coverage rate on children's hospital admissions was estimated using the vaccination rates of children aged <6 years and age 6 to 11 years, and compared to the effect on hospital admission rates during the influenza peak week in 2017, 2018 and 2019, for the associated age groups.

Table 1. Comparison of vaccination rates between the two survey years.

	Influenza vaccination rate (2018/2019)	Influenza vaccination rate (2019/2020)	<i>p</i> -Value
Surveyed children from SOV schools (7–11 years old)	1572/2272 (69.2%)	1575/2266 (69.5%)	0.8428
Preschool (0–3 years old)	377/953 (40.0%)	79/215 (36.7%)	0.4921
Kindergarten (4–6 years old)	309/752 (41.1%)	250/413 (60.5%)	0.0001
Secondary School (12–17 years old)	133/612 (21.7%)	197/561 (35.1%)	0.0001
Adults (18–under 64)	712/5134 (13.9%)	511/4539 (11.3%)	0.0001
Senior Citizen (age 64 above)	329/752 (43.8%)	110/240 (45.8%)	0.6233

Result

There was no significant difference in the influenza vaccination rate of primary school children between the two survey years, 69.2% versus 69.5% ($p = .8428$) (Table 1). There was a significant increase in the vaccination rate for kindergarten children between the two survey years, with a rate of 41.1% versus 60.5% ($p = .001$) (Table 1). The slight decrease of vaccination rate for adults was statistically significant, i.e., 13.9% versus 11.3% ($p = .001$). For preschool children and senior citizens, there were no significant differences in their influenza vaccination rates between the two survey years with the rate of 40.0% versus 36.7% ($p = .4921$) and the rate of 43.8% versus 45.8% ($p = .6233$) respectively (Table 1).

The number of vaccine recipients estimated in this study was not significantly different from the CHP records for the three age groups covered by the Government universal vaccination program. The vaccination rates for the age groups specified in Table 2 are in line with the 95% confidence limit (Table 2). The vaccination rate was lowest among adults aged 18–39, ranging from 3.6% to 8.1%, while the rate was highest among school-aged children with the rate varying up to 69.50% (Table 2). The influenza vaccination rate in adulthood was relatively low compared to other age groups (Table 2). The SOV ensures that primary school children's influenza vaccination coverage rate in Hong Kong is now comparable with that of other countries.^{17–21} However, available data for adulthood vaccination rates in other countries could not be identified for comparison. The data estimated by CHP demonstrated that the vaccination rates have been increasing since 2017 for all children under 12 years old (Figure 1).

During the influenza season, the number of hospital admissions for children aged under 6 years old was much higher than children aged 6 to 11. The SOV program increased the vaccination rate from 20.5% in 2018 to 55.4% in 2019 for children aged 6 to 11 years, associated with a decrease in influenza hospital admissions from 200 to 115 during the influenza peak week, whereas admissions for children aged <6 years increased from 446 to 569. Subsequently, in 2020 the SOV program expanded resulting in vaccination rates of 47.4% and 68.1% for children aged under 6 years old and 6 to 11 years old respectively, with admissions reducing further to 235 and 62 respectively. 1% increase in vaccination coverage was associated with a reduction of 4.3 influenza related hospital admissions.

Table 2. Estimated vaccination rates according to survey results in comparison to CHP Government statistics.

Age	Vaccination rate in 2020% (95% C.I.)	Vaccination rate as per CHP in 2020 (%)
0–5 years	48.5 (44.3–53.0)	47.4
6–11 years	69.30 (67.6–71.3)	68.1
12–17 years	32.9 (28.2–37.2)	
18–19 years	6.2 (2.4–14.8)	
20–29 years	3.6 (1.7–7.7)	
30–39 years	8.1 (6.8–9.6)	
40–49 years	13.1 (11.8–14.6)	
50–64 years	14.3 (11.7–17.4)	
65–89 years	45.7 (39.5–52.0)	45.8

CHP: Center for Health Protection.
C.I.: Confidence Interval.

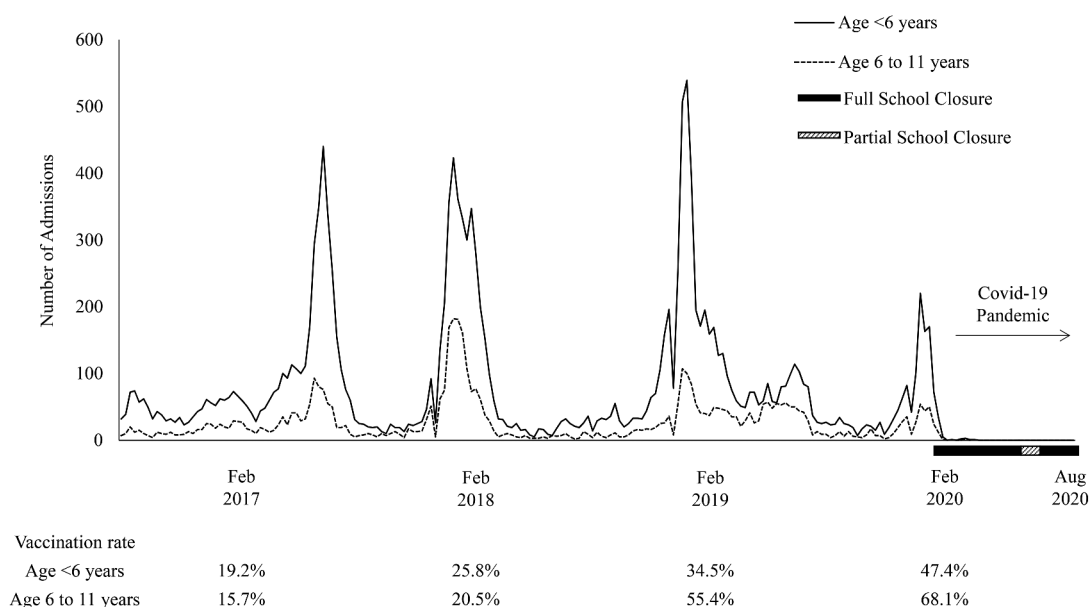


Figure 1. The number of weekly influenza related hospital admissions over time in children aged under 6 years old in comparison to those aged 6 to 11 years old and their corresponding vaccination rates.

Discussion

The SOV program maintained the same influenza vaccination rate among primary school students over the two study years.¹⁰ According to the CHP, a pilot run of the SOV in kindergartens was started in 2019.⁹ Therefore, there was a significant increase in the influenza vaccination rate for kindergarten students for that year. Without any intervention, there was no significant change in vaccination rate among other age groups. The estimated vaccination rates in the study were comparable with the CHP data for those under 12 years old and over 65 years old. This close matching validates the questionnaire based tool used in accurately estimating the influenza vaccination rate in other specific age groups.

This study demonstrated that the influenza vaccination rate was under 10% among the population aged between 18 and 39 years old. The vaccination rate for primary school students has been improving from 15.7% in 2017 to 68.1% in 2020 with the phased implementation of SOV, it is possible that other factors, such as education and social media also contributed to the increased vaccination rate but rates now remain at a high level and are comparable with other countries.^{5,17–23} However, there is still room for improvement for other age groups.

Studies have suggested that, in non-at risk patients with medium to high efficacy vaccines, the majority of influenza strains need a vaccination rate of at least 40–50% to reach herd immunity and a vaccination rate of reaching this can have a significant impact on school attendances and hospital admissions.^{6,24,25} This study suggests that this is also true in Hong Kong, because when the vaccination rate was greater than 50% there was a marked reduction in influenza-related hospital admissions in children aged 6 to 11 years old. The roll-out of influenza vaccination to other age groups is likely to be beneficial to the total population. However, the indirect impact of the increasing pediatric vaccination rate on other age groups and the total population is beyond the scope of this project but should be considered in future research.⁶

The Non-Pharmaceutical Interventions (NPIs) implemented in Hong Kong due to the COVID-19 pandemic are the major confounding factors in our study. Due to the NPIs started in late January 2020, including the closure of schools, the influenza peak of 2020 could not fully develop, and the number of influenza hospital admissions may be underestimated. The NPI measures in force not only prevented the transmission of COVID-19 but also influenza (Figure 1) with CHP reporting <0.1% influenza positive results from Nasopharyngeal Aspirates (NPA) samples per 1,000 influenza like illness consultations,²⁶ resulting in the near absence of influenza-related admissions during this time frame. Aside from this, vaccination status was self-reported potentially leading to recall bias and influenza diagnostic tests may vary for patients presenting with influenza like symptoms predisposing to potential underestimation. These confounding factors are beyond the control of this current research and further investigation is needed to know the impact of these social measures on the predicted reduction of hospital admissions in the unvaccinated population.

Conclusion

The SOV program significantly improved the primary school students' vaccination rate and therefore substantially reduced the number of influenza-related hospital admissions. This data provides the rationale that this program should be promoted to all kindergartens, secondary schools, and childcare centers. The vaccination coverage rate of young adults is low in Hong Kong because they are currently not targeted for intervention, specific strategies for promoting influenza vaccination should focus on them now. Considering the need for rapid implementation of universal vaccination to curb the COVID-19 pandemic, this current experience of influenza vaccine SOV could be expanded to cover COVID-19 vaccine administration for school children. The dramatic effect of COVID-19 social distancing policies on reducing influenza cases to near zero

also demonstrates how to employ NPI in reducing hospital admissions during future influenza outbreaks.

Ethical approval and informed consent

This study has been approved by the Hong Kong University/ Hospital Authority Hong Kong West Cluster IRB Committee (IRB No: UW 17-111). Informed consent was collected from all those participating.

Disclosure statement

All authors report no conflicts of interest.

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Authors contributions

Yu Lung Lau: Principal investigator responsible for; conceptualization, study design, writing and editing of the manuscript. Wilfred Wong: Responsible for statistical analysis. Chun Bong Chow: Responsible for study design. Sinéad Peare: Responsible for data analysis and writing of the manuscript. Hiu Ying Lam: Responsible for data collection, data curation and communication with participating schools.

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Appendix A

To parents:

Class: _____ Sex: *Male/Female Age: _____

Residential Building/Estate Name: _____

Living area: less than 20 m² (less than 215 ft²) 20–39 m² (215–419 ft²)
 40–69 m² (420–749 ft²) 70 m² and above (750 ft² and above)

Questionnaire

The surveyed child represents the child who is selected to participate in the survey and if more than one child in your household is selected, please fill in one questionnaire for each child and please check the box to indicate the correct answer.

	Has the family member received flu vaccination during the past year?		During the last month, has the below family member been sick with a fever of >38°C and cough?		Has the family member hospitalized during the past month? If yes, please write down the number of days he/ she have been hospitalized.	
	Yes	No	Yes	No	Yes	No
Family member						
The surveyed child	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Father	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____						
Mother	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____						
Bother/Sister (1)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____						
Bother/Sister (2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____						
Bother/Sister (3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____						
Bother/Sister (4)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____						
Other family member (1)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____ * Male /Female						
Other family member (2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____ * Male /Female						
Other family member (3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____ * Male /Female						
Other family member (4)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> : ____ day	<input type="checkbox"/>
Age: _____ * Male /Female						

* Please delete as appropriate!