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Evaluation of the Effectiveness of Influenza Vaccination among Primary School Students in Fangshan District, Beijing

Jinyi Liu [1, *]

[1] Beijing Luhe International Education Academy School, Beijing, 101149, China

*Corresponding author: jinyiliu625@gmail.com

Abstract:

Influenza (hereinafter referred to as "influenza") is an acute respiratory infectious disease caused by influenza virus, which is seriously harmful to human health. Its antigenicity is variable and spreads rapidly. It can cause seasonal epidemics every year. People are generally susceptible to influenza virus. Pregnant women, infants, the elderly, patients with chronic diseases and other high-risk groups are more serious after infected with influenza virus. Influenza outbreaks are easy to occur in schools, kindergartens, nursing homes and other places where people gather. Annual influenza vaccination is an effective means to prevent influenza and reduce the burden of influenza related severe illness and death. It can reduce the health hazards caused by influenza related diseases and the run on medical resources. Therefore, the data of free influenza vaccination among primary school students in Fangshan District of Beijing in 2023 and the survey data of influenza clustering in the influenza epidemic season from 2023 to 2024 were selected to evaluate the vaccination rate and the protection effect of influenza vaccine.

Keywords: Influenza; influenza vaccine; vaccination rate; primary school students; evaluation.

1. Introduction

Influenza (hereinafter referred to as "influenza") is an acute respiratory infectious disease caused by influenza virus, which is harmful to human health. Its antigenicity is changeable and spreads rapidly, which can cause seasonal epidemic every year. People are generally susceptible to influenza virus, and the harm is more serious after high-risk groups such as pregnant women, infants, the elderly and patients with chronic diseases are infected with influenza virus, and influenza outbreaks are prone to occur in places where people gather, such as schools, kindergartens and nursing homes [1]. Vaccination against influenza every year is an effective means to prevent influenza and reduce the burden of influenza-related severe illness and death, which can reduce the health hazards caused by influenza-related diseases and the run on medical resources. According to statistics, the annual flu season can lead to 3-5 million severe cases and 290-650,000 deaths worldwide [2]. As a populous country, China is also a country with high incidence

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of influenza. In the northern and southern cities of China, the average annual excess mortality rate of influenza-related respiratory and circulatory diseases is 12.4/100,000 and 8.8/100,000 respectively [3]. Therefore, influenza vaccination is recommended by WHO and many countries and regions as an effective means to prevent influenza infection and reduce serious complications [4, 5].

Since 2007, Beijing has implemented a free influenza vaccination policy, providing free influenza vaccination services for all primary and secondary school students. Chang confirmed the infection of seasonal influenza virus through mouse model, which caused most people in the population to have immune memory of influenza virus. The existence of this memory can weaken the infection of influenza virus to some extent, but it can not completely fight against the mutated influenza virus [6]. Xu et al. used the dynamic model of susceptible-The Infiltrator-dominant infected person/recessive infected person-mover/restorer to simulate the previous epidemic data, calculated the cumulative attack rate to evaluate the vaccination effect, and calculated the cost-effectiveness and cost-effectiveness for health economic evaluation. Finally, it was pointed out that the higher the influenza vaccination rate, the better the cost-effectiveness and the higher the cost-effectiveness of the vaccine [7]. Zhang et al. collected the case information of cluster fever and influenza-like cases (ILI) among primary and secondary school students in Beijing from November to December, 2014 and the history of influenza vaccination, and analyzed the protective effect of influenza vaccine on ILI cases and laboratory-confirmed influenza cases by case-control study. The study concluded that the group vaccination of influenza vaccine among primary and secondary school students had certain protective effect on influenza [8]. Sun from the Immune Center of China CDC pointed out through the analysis of the monitoring data of three influenza epidemic seasons from the 27th week of 2017 to the 26th week of 2020 that vaccination against influenza among school-age children can prevent the occurrence of influenza, especially the cluster influenza in schools. At the same time, it is also found that when the influenza vaccination rate reaches a certain threshold, the effect of preventing influenza is better [9]. After studying the effect of influenza vaccine in epidemic season from 2019 to 2020, Yang pointed out that the influenza vaccine on the market has a moderate protective effect. The protection effect of influenza vaccination for people aged 6-18 is better than that of the elderly aged 60 and above, and the infection risk of people with basic diseases is reduced by 48% [10].

However, at present, there are few studies on the protective effect of influenza vaccination on influenza clustering epidemic among primary school students in Fangshan District. The purpose of this paper is to analyze the vaccination of primary school students in Fengtai District of Beijing in 2023 and the protective effect of the vaccine in the event of influenza epidemic in the influenza epidemic season.

2. Methods

2.1 Data Source

Data on centralized vaccination of free influenza vaccine in primary schools in Fengtai District of Beijing in 2023, and survey data on influenza epidemic situation in 2023-2024.

2.2 Vaccination Data

It is reported by the full-time doctors of the community health service center in Fangshan District who undertake the vaccination task, including the school name, school nature, street and township, geographical location, number of registered students, number of people vaccinated with influenza vaccine, vaccination time, etc. of all primary schools in the jurisdiction in 2023. Influenza clustering epidemic is an influenza clustering epidemic, which is checked, processed and confirmed by Fangshan District Center for Disease Control and Prevention (hereinafter referred to as CDC) according to the Beijing influenza monitoring and epidemic disposal work plan, and students' physical condition is registered in the morning and afternoon by school doctors in each school within their jurisdiction and they are absent from work due to illness every day. In the process of dealing with the epidemic situation, the names of the schools where the epidemic situation occurred, the classes where the epidemic situation occurred, the number of people, the influenza vaccination situation and other information were collected.

2.3 Related Concepts

Influenza epidemic season: The influenza epidemic season in Beijing is from September to April of the following year, and the research time is from the 35th week of 2023 to the 18th week of 2024.

Reporting standard of concentrated fever epidemic situation: there are more than 5 cases (including 5 cases) of patients with concentrated fever (body temperature ≥37.5℃) in the same class or department of a collective unit in a school, or more than 3 cases (including 3 cases) in the same dormitory or office.

Reporting standard for outbreak of influenza-like cases: within one week, 10 or more influenza-like cases (fever: underarm temperature ⩾38¡æ, accompanied by cough or sore throat) occurred in the same school, nursery institu-

tion or other collective units. Influenza-like cases need to have epidemiological correlation.

$$X = \frac{Y - Z}{Y} * 100\% \quad (1)$$

Where X represents the protection rate of influenza vaccine, Y represents the incidence rate of unvaccinated group, Z represents the incidence rate of vaccinated group. In this paper, the specific use of influenza epidemic season in 2023-2024 in the class, the incidence of students vaccinated with influenza vaccine and the incidence of students not vaccinated with influenza vaccine to calculate the vaccine protection.

$$W = \frac{Y}{Z} * 100\% \quad (2)$$

Where W stands for effect index, Y represents the incidence rate of unvaccinated group, Z represents the incidence rate of vaccinated group. In this paper, the ratio of influenza incidence rate of students who have not been vaccinated with influenza vaccine to that of students who have been vaccinated with influenza vaccine during the influenza epidemic season in 2023-2024.

School size: according to the trinket of the number of students enrolled in the school, it is divided into three groups: small-scale, medium-scale and large-scale, in which the number of students enrolled is ≤478 for small-scale, between 479 and 697 for medium-scale and ≥698 for large-scale.

2.4 Statistical Processing

Epi Data software was used to establish the database, and SAS 9. 4 statistical software was used for data analysis. The number and percentage of cases were used to describe the classified data, $\chi 2$ test was used to compare the differences between groups, and $\chi 2$ trend test was used to analyze the trend. $P < 0.05$ is statistically significant.

3. Results and Discussion

3.1 Influenza Vaccination Situation

In 2023, among 108 primary schools and their branches in Fangshan District, 107 schools were vaccinated with free influenza vaccine, with 71,103 registered students and 35,721 vaccinated people, with a vaccination rate of 50. 24%. The median vaccination rate of 107 primary schools was 53. 65%, the quartile was 43. 60% and 63. 41% respectively, and the lowest and highest vaccination rates were 24. 56% and 91. 37% respectively. There is no difference in the vaccination rate of students in different schools, but there are differences in the vaccination rate of influenza in different schools in terms of school size, street township, school geographical location and vaccination time. According to the further analysis of the number, scale and recurrence cases of influenza clustering epidemic in 2017-2018, it shows that the lower the vaccination rate, the more the number and scale of influenza clustering epidemic occur in schools, and the higher the probability of recurrence cases after the epidemic occurs, as shown in Table 1.

Table 1. Centralized influenza vaccination in 107 primary schools and their branches in Fangshan District, Beijing in 2023

group	number of schools	headcount	vaccination number	Inoculation rate	$\chi 2$ value	P value
School nature					0.066	0.0797
public	100	65687	32991	50.22		
private	7	5416	2730	50.41		
School size					1342.771	<0.001
big	36	38441	17015	44.26		
medium	36	21303	11678	54.82		
small	35	11359	7028	61.87		
Streets/ towns					228.955	<0.001
streets	80	53924	26227	48.64		
towns	27	17179	9494	5.27		
Geographical position					425.931	<0.001
west	15	12166	5639	46.35		
middle	42	31833	15137	47.55		
east	50	27104	14945	55.14		

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Vaccination time (month)					127.283	<0.001
9	65	42460	21694	51.09		
10	40	26407	13155	49.82		
11	2	22236	872	39		
Number of epidemic situations (from)					443.685	<0.001
>3	4	4775	1975	41.36		
2	7	6722	2893	43.04		
1	12	8143	3799	46.45		
0	84	51463	270054	52.57		
Epidemic scale (from)					410.969	<0.001
outbreak	6	6946	2984	42.96		
centralized fever	17	12694	5683	44.77		
no epidemic situation	84	51463	27054	52.57		
secondary case					425.824	<0.001
yes	10	8928	3781	42.35		
no	13	10712	4886	45.61		
sum total	107	71103	35721	50.24		

3.2 Vaccination Rate and Vaccine Protection Effect

During the influenza epidemic season from 2023 to 2024, 23 primary schools in the whole region reported 39 cases of influenza clustering confirmed by laboratory tests, involving 42 classes, 1 488 students and 408 cases, with an overall incidence rate of 27. 42%. The influenza vaccination rate of students in the affected classes was 37. 90%, which was lower than the average vaccination rate of primary schools in the whole region of 50. 24% ($\chi2$= 88. 701, P < 0.001). The incidence of influenza among primary school students in the vaccinated group was 22. 70%, while that in the uninoculated group was 30. 30%. The difference between the two groups was statistically significant ($\chi2$= 10. 186, P =0. 001). The vaccine protection rate was 25. 11%, and the effect index was 1. 34. Further grouping analysis according to school size, street, geographical location, vaccination time, gender and grade showed that there was significant difference in the incidence rate between small-scale schools, streets, eastern regions, September vaccination, male, senior and junior students vaccinated group and non-vaccinated group during the outbreak of influenza cluster epidemic. On the whole, the vaccine protection effect is better in small-scale schools, economically developed areas, early vaccination time, male and senior students, as shown in Table 2.

Table 2. Influenza incidence and vaccine protection effect of vaccinated and unvaccinated students in vaccinated and unvaccinated classes with epidemic situation in vaccinated and unvaccinated groups

Group	headcount Inoculation rate	Inoculation group		Inoculated group		$\chi2$ value	P value	vaccine of protection	effect
		number of people	incidence rate	number of people	incidence rate				
School size									
small	221(56.11)	124	24(19.35)	97	33(34.02)	6.116	0.013	43.12	1.76
medium	365(36.44)	133	31(22.31)	232	74(31.90)	3.043	0.081	30.06	1.43
big	902(34.04)	307	73(23.78)	595	173(29.08)	2.865	0.091	18.23	1.22
Streets/ towns									
streets	1057(37.75)	399	78(19.55)	658	193(29.33)	12.467	<0.01	33.35	1.50
towns	431(38.28)	165	50(30.30)	266	87(32.71)	0.271	0.602	7.35	1.08

Geographical position									
west	433(33.26)	144	36(25.00)	289	93(32.18)	2.369	0.124	22.31	1.29
middle	628(40.61)	255	55(21.57)	373	99(26.54)	2.024	0.155	18.74	1.23
east	427(38.64)	165	37(2.42)	262	88(33.59)	6.094	0.014	33.24	1.50
Vaccination time (month)									
9	866(38.34)	332	73(21.99)	534	166(31.09)	8.481	0.004	29.27	1.41
10	622(37.30)	232	55(23.71)	390	114(29.23)	2.243	0.134	18.90	1.23
11	()								
Gender									
male	772(38.08)	294	58(19.73)	478	145(30.33)	10.567	0.001	34.97	1.54
female	716(37.71)	270	70(25.93)	466	135(30.27)	1.553	0.213	14.35	1.17
Grade									
grade 1-3	1010(37.23)	376	96(25.53)	634	206(32.49)	5.455	0.020	21.42	1.27
grade 4-6	()								
sum total	1488(37.90)	564	128(22.70)	924	280(30.30)	10.186	0.001	25.11	1.34

Note: During the influenza epidemic season of 2023-2024, the non-governmental schools and the schools that carried out influenza vaccination in November did not report the influenza clustering epidemic.

3.3 Discussion

Influenza is susceptible to the whole population. Compared with other populations, school-age children have the highest infection rate and play an important role in the spread of influenza in schools, families and communities. Since the implementation of the policy of reducing free influenza vaccination for primary and secondary school students in Beijing in 2007, the influenza vaccination rate of students has always remained above 50%. The elimination of cost obstacles and the guarantee of service accessibility have greatly promoted the promotion of influenza vaccine among Beijing residents. According to the statistics of the special report on influenza vaccination in Beijing in 2023, the influenza vaccination rate of primary and middle school students in Beijing is 63. 7%. Investigation on the current situation of influenza vaccination among primary and secondary school students in Fangshan District from 2015 to 2016 showed that the influenza vaccination rate of primary school students in Fangshan District was 42. 05%. The survey results show that the influenza vaccination rate of primary school students in Fangshan District is 50. 24% in 2023. Although the vaccination rate is higher than before, it is lower than the city average. Some studies believe that an effective immune barrier can only be formed if the vaccination rate reaches more than 60%, and the vaccination rate of primary schools in Fengtai District needs to be further improved. Fengtai District, located in the southwest of Beijing, is a typical urban-rural junction. This study suggests that the vaccination rate of influenza in schools located in the streets is higher than that in township schools. Fengtai District is long and narrow, with a relatively high economic level in the east and underdeveloped in the west, and the influenza vaccination rate is decreasing from east to west. Previous studies have also suggested that the vaccination rate in Beijing urban area is much higher than that in suburban counties, which may be related to the higher education level of residents in economically developed areas, deeper understanding of vaccines and better understanding of relevant vaccination policies. The vaccination work of influenza vaccines in township schools and western schools in Fengtai District should be strengthened.

This study shows that the vaccination rate of influenza vaccine is different in schools with different school sizes. With the increase of the number of students, the vaccination rate of influenza vaccine decreases, which may be related to the difficulty of management and health education and health policy implementation in schools with large school sizes. The specific reasons need to be further explored. It is generally believed that antibodies with protective level can be produced in about 2 ~ 4 weeks after influenza vaccination.

Studies have shown that the incidence rate of students vaccinated in September during the outbreak of influenza cluster was lower than that of the unvaccinated group. There was no significant difference in the incidence of influenza between the vaccinated group and the unvaccinated group in October. It is suggested that the promotion

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of influenza vaccination should be supported by sufficient human and material resources, and timely vaccination should be carried out before the influenza epidemic season to give full play to the protective effect of the vaccine.

Vaccination against influenza is the most effective means to prevent influenza, and many studies suggest that vaccination against influenza has obvious preventive effect in the whole population and children. Centralized vaccination of influenza vaccine in schools can achieve high coverage in a short time and greatly reduce the risk of influenza clustering epidemic. This study shows that in schools with high influenza vaccination rate, the number of influenza epidemics is small, the scale is small, and the probability of recurrent cases is small. A study in Beijing shows that influenza vaccination can reduce the epidemic situation of influenza aggregation by 11%, which is consistent with this study.

The results of two community intervention experiments in the United States show that the protection rate of influenza vaccine among students is between 30% and 35%, but there is a lack of reference on the data of vaccine protection rate of influenza vaccine in influenza epidemic.

This study shows that the overall vaccine protection rate of influenza vaccination in influenza epidemic is 25. 11%, which shows that influenza vaccination can effectively protect students in influenza epidemic. However, at present, some parents still refuse to vaccinate their children with influenza because of their low level of vaccine knowledge and even misunderstanding, such as fear of adverse reactions, thinking that vaccination does not work, and thinking that it is not necessary to vaccinate their children in good health. In this regard, the author should strengthen health education and public communication, widely participate in the community, and effectively cooperate with medical institutions to guide parents to form a correct understanding of influenza vaccine, improve vaccination rate, so as to reduce the occurrence of influenza epidemic and play a protective role during the influenza epidemic.

4. Conclusion

Through the research in this article, it can be concluded that although the price of crude oil may slightly increase in the short term, the overall trend of change in the next year will still decrease. However, due to the uncertainty of the international economic situation, predictions made further away will become more inaccurate. Meanwhile, in recent years, the world has been affected by the pandemic, and the economies of various countries have been impacted and are in a recovery period, which will make oil prices more difficult to predict.

Through the predictions and research in this article, some suggestions can be provided. From an individual perspective, it is not a reasonable choice for crude oil investors to make relevant investments shortly. From a national perspective, the government should try to minimize the impact of the international economic situation on the domestic market. This can not only maintain a stable development trend of the domestic economy, protect domestic enterprises from international economic shocks, and maintain social stability, but also serve as feedback, and more intuitively and accurately trade various international goods while ensuring domestic stability. This not only benefits the international crude oil market but also puts the country as a whole in an advantageous position in international trade.

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