

# Research on the Influencing Factors of the Spread of Chickenpox

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**Abstract.** Chickenpox is an infectious disease that spreads and occurs extremely quickly due to the varicella-zoster virus. It not only causes respiratory infections, but also usually causes a series of complications. Although previous studies have shown that the incidence of chickenpox is related to climate change, air pollutants and vaccination, there are still many uncertain factors that can be studied. In this study, the logical regression model method was used to sort out the statistical data from several cities in China. The statistical table counted the number of patients from 2018 to 2020. Conclusion: Although chickenpox has nothing to do with school pattern, and education level, it has a strong relationship with seasons, population density, population mobility, and extreme weather. which have never appeared in previous studies, which provides some new suggestions for the etiology and prevention of chickenpox. If further medical investigation is conducted on these factors, it means that they can be inspired in future research on chickenpox prevention.

**Keywords:** Chickenpox; influencing factors; descriptive analysis.

## 1. Introduction

Chickenpox is an acute infectious disease caused by Varicella zoster virus (VZV) infection. Xin et al. analyzed three different provinces in southern, central, and northern China in August 2020, and extracted data on the vaccination and management of chickenpox vaccines in five cities [1]. They concluded that different vaccine procurement and distribution strategies were adopted, and education on willingness to vaccinate against chickenpox was strengthened. In addition, Sui concluded that two doses of vaccination have a stronger protective effect than one dose [2]. In the past 5 years, the PHEE of chickenpox in China has shown an upward trend and obvious seasonality, with the main target group being adolescents or children [3, 4]. Therefore, understanding the factors that lead to the high prevalence of varicella infection is particularly critical to prevent and protect the incidence rate of children. The central idea of this article is to study the potential factors that may lead to the spread of chickenpox and help people better prevent it.

The infectious factors of varicella are very large and complex. The incidence rate of varicella is affected by the superposition of many factors [5]. Through data analysis, some scholars have found that vaccination [6], population mobility [7], population policies [8], and some other factors have a certain impact [9, 10]. However, these literatures are relatively targeted and cannot summarize most of the influencing factors, lacking overall data changes. Therefore, this paper uses eight influencing factors (vaccination, population mobility, population policy, season, age group, public health, gender, socio-economic factors) to study, to explore their impact on the incidence rate and their correlation in transmission.

Wei used the Reed Frost model to analyze the incidence trend of chickenpox in his research [11]. When the indicator set  $U$  is large, under the constraint of a weight vector sum of 1, the relative membership weight coefficient often tends to be small, and the weight vector does not match the fuzzy matrix  $R$ , resulting in a super blurry appearance with poor resolution, making it difficult to distinguish who has a higher membership degree. In severe cases, it may even lead to evaluation failure. Hu used the propagation dynamics model to conduct research [12]. The classification of the influencing factors of the model was not detailed enough, and some improvements could not be reflected in the past data. The existing data was not enough to reflect the impact of these factors on the incidence of varicella. Xu predicted using the Holt - Winters product model [13], and when  $k$  was

small, the predicted data smoothing effect was not significant, and it highlighted the recent changes in the data; When k is large, although there is a good smoothing effect, there is a delay in the predicted data. And at least k values are required.

In conclusion, this paper will use a logistic regression model to study the impact of these eight factors on the incidence of varicella, that is, whether they are factors leading to varicella transmission.

## 2. Methods

### 2.1. Data Sources

This study is based on the China Disease Prevention and Control Information System to collect varicella cases and public health emergency events (PHEEs) from 2016 to 2020 in China.

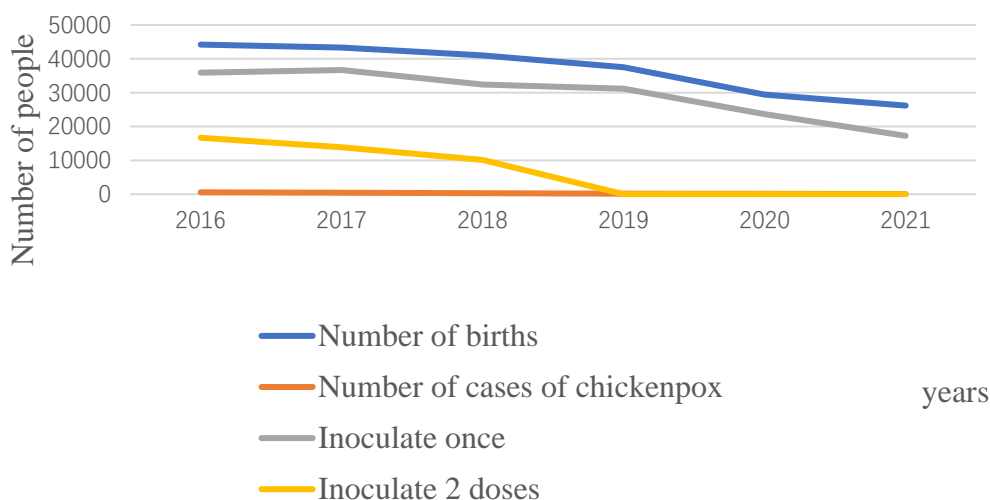
### 2.2. Variable Selection

In this study, the factors affecting varicella infection and the impact of varicella incidence rate were refined. Firstly, the dependent variable influencing factors are subdivided into the number of PHEE reports for chickenpox, number of chickenpox cases, and incidence rate (number of chickenpox cases/number of affected individuals) × 100%) and other indicators. Secondly, the independent variables include vaccination, population mobility, population policy, season, age group, etc. (Table 1).

**Table 1.** Vaccination and incidence

Year of birth	Number of births	Number of cases of chickenpox	Inoculate once	Inoculate 2 doses
2016	44205	554	35908	16670
2017	43332	451	36693	13860
2018	41025	306	32397	10127
2019	37502	168	31183	-
2020	29447	120	23660	-
2021	26176	52	17240	-
Total	221687	1651	177081	40657

Table 1 shows the total number of people, the number of varicella patients, and the number of people vaccinated. As shown in Table 1, the data sample consists of 43663 births per year, of which 1100 have chickenpox. Among the 43663 people, 24936 received the first vaccine and 3799 received the second vaccine.



**Fig. 1** Vaccination and incidence plot

According to Figure 1, it can be observed that the number of vaccinated individuals has sharply decreased in recent years. Although the birth population is also decreasing, the overall vaccination

rate is showing a downward trend. And the number of patients is also decreasing year by year. According to Figure 1, the factors that affect the incidence rate of varicella are not high when the vaccination proportion decreases.

### 3. Results and Discussion

#### 3.1. Correlation Analysis

According to this data analysis, it can be found that whenever the number of patients increases, people often choose to have more people vaccinated to control the infection and reduce the number of patients in order to resist. This results in a very high correlation coefficient between them of over 0.97. It can also be found that vaccination is extremely important for isolating the spread of chickenpox and is also one of the important means for people to prevent chickenpox (Table 2).

**Table 2.** Analysis of the correlation between vaccination and diseased individuals

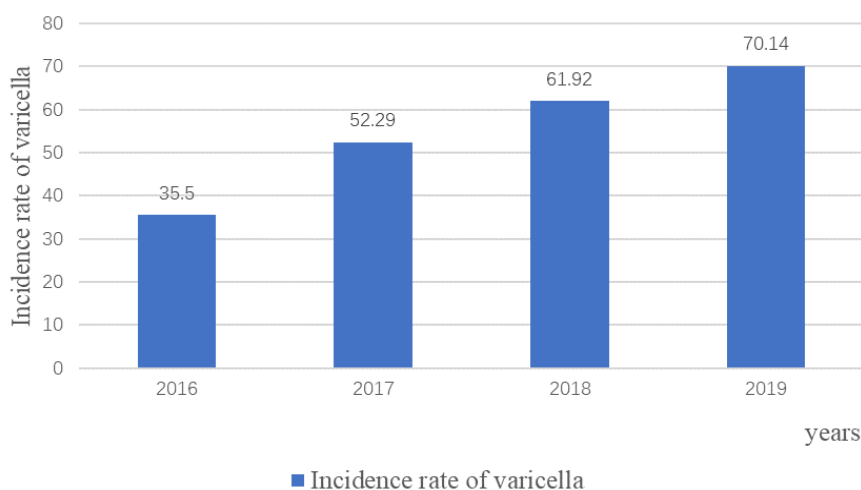
Variable	correlation	sufferer
Number of births	correlation coefficient	0.970**
	P-value	0.000
	sample size	7
First vaccination	correlation coefficient	0.973**
	P-value	0.000
	sample size	7
Second vaccination	correlation coefficient	1.000**
	P-value	0.000
	sample size	4

\* p<0.05 \*\* p<0.01

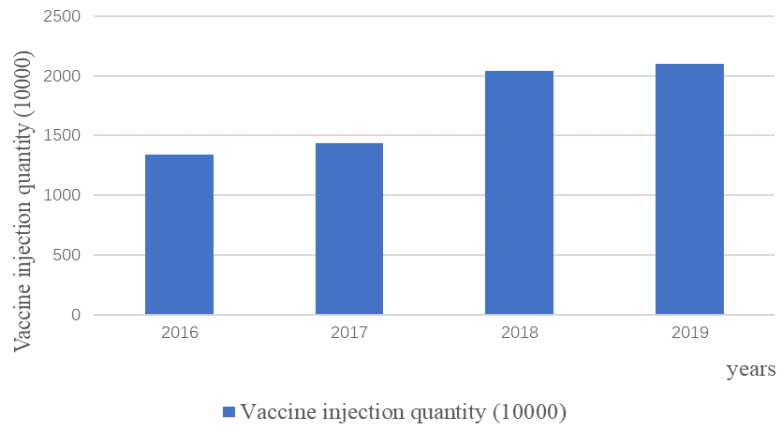
#### 3.2. The Impact of Vaccines on Disease Transmission

Due to the large number of vaccinated individuals, the proportion of cases is much higher than that of vaccinated individuals in most cases, which undoubtedly indicates that although vaccines have great protective effects on individuals, they cannot prevent the spread of the virus on a large scale.

Figure 2 shows the incidence rate of varicella in China from 2016 to 2019, from which it can be seen that the probability is in the form of continuous growth, and the incidence rate reached 70.14% when it was the highest. And according to the comparison of the number of vaccine output in China in Figure 3, it can be found that although the vaccine output is also increasing year by year. However, the increase of incidence rate cannot be suppressed. So, it can be preliminarily concluded that the inhibitory effect of the vaccine on the transmission of chickenpox is difficult to be reflected before the nationwide vaccination is completed.



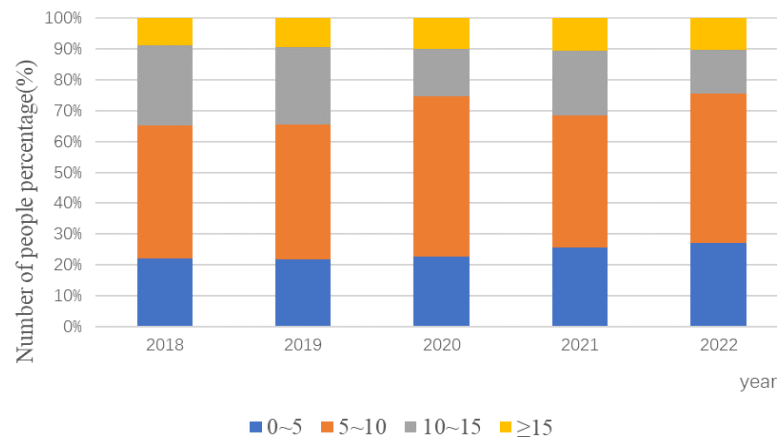
**Fig. 2** Change in incidence rate of varicella from 2016 to 2019



**Fig. 3** Vaccination volume from 2016 to 2019

### 3.3. Age Group Changes in Chickenpox Infection

According to statistics from Chongqing, approximately 46.2% of varicella zoster infected individuals are primary school students and children aged 5-10. There are also children under the age of 5, accounting for approximately 24% (Fig 4).



**Fig. 4** Distribution of varicella virus in different age groups

**Table 3.** Correlation analysis between age groups and overall samples

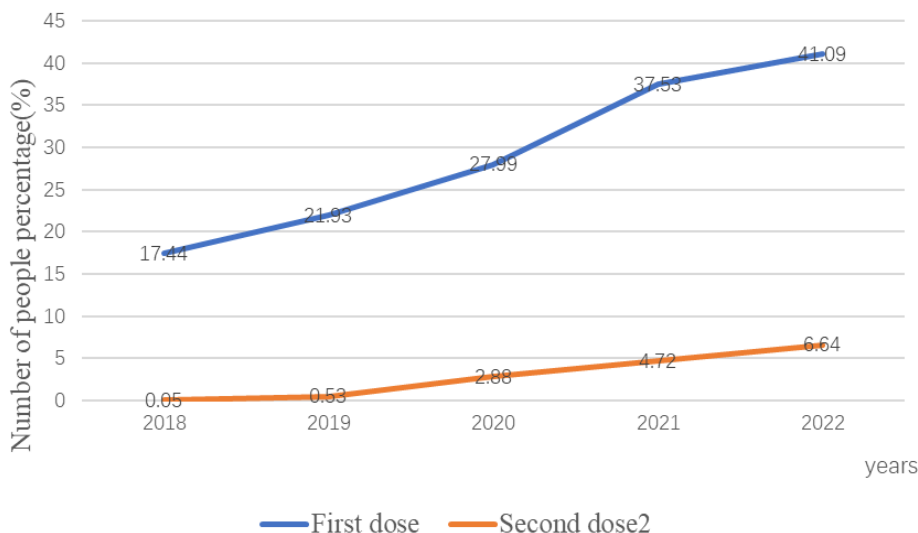
Variable	correlation	Total samples
0~5	correlation coefficient	0.791
	P-value	0.111
	sample size	5
5~10	correlation coefficient	0.900*
	P-value	0.037
	sample size	5
10~15	correlation coefficient	0.337
	P-value	0.579
	sample size	5
≥15	correlation coefficient	0.914*
	P-value	0.030
	sample size	5

\* p<0.05 \*\* p<0.01

This data indicates the correlation between each age group and the overall prevalence of the disease, and it can be found that the prevalence rate of people over 15 years old has always been closely related to the overall population in each year. In addition, patients aged 5-10 also maintain a very high

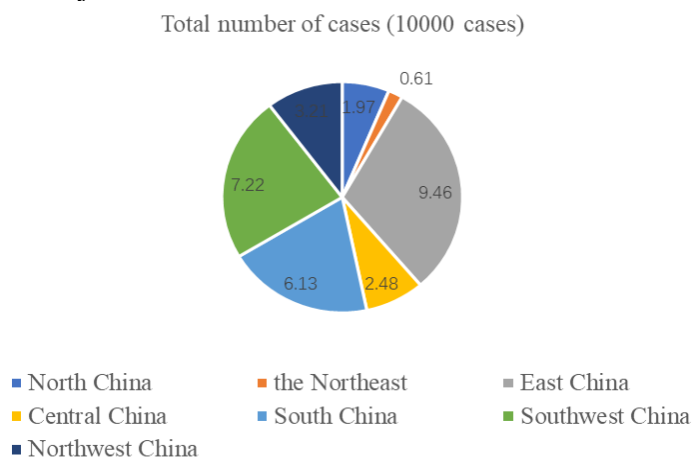
correlation coefficient. However, the correlation between the ages of 0 to 5 remains relatively low, while patients aged 10 to 15 have almost no correlation with the overall sample. It can be found that in most age groups, the incidence rate has a strong functional relationship with the whole, but in the range of 10-15 years old, they will not be strongly affected about the whole sample (Table 3).

The main age group for chickenpox in China is children under the age of 15, accounting for 90% of the total sample. The high incidence of chickenpox is mainly among students and young children, with students accounting for the highest proportion.



**Fig. 5** Changes in vaccination rates between 2018 and 2022

According to the comparison in Figure 5, although the vaccination rate has been continuously increasing nowadays. This indicates that receiving one dose of chickenpox vaccine is prone to immune unresponsiveness and has a high breakthrough rate. Therefore, it is necessary to strengthen the second dose of vaccine injection.



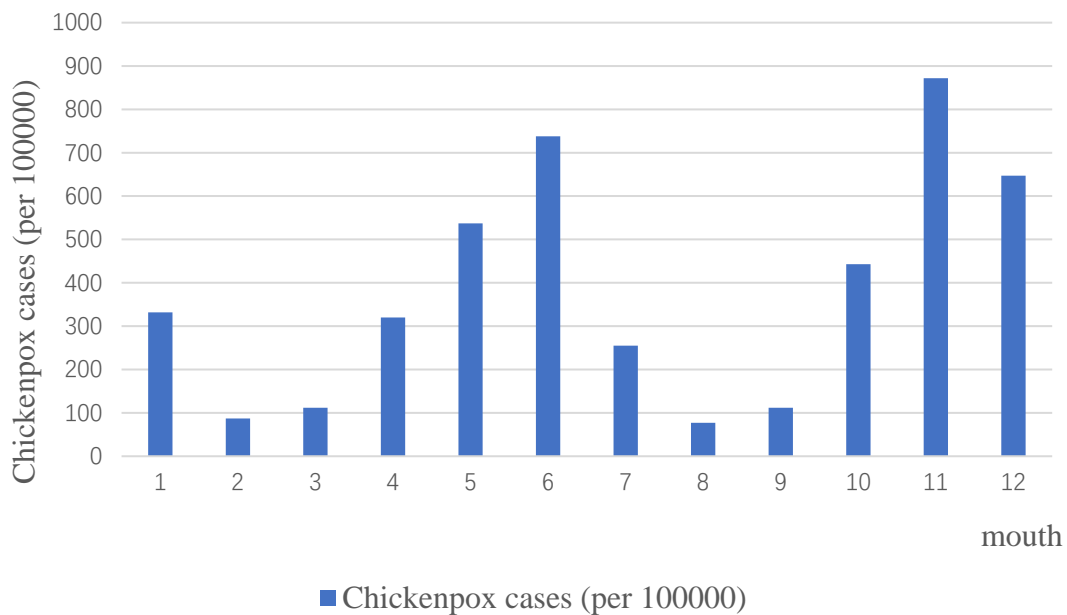
**Fig. 6** Proportion of Vaccine Infected Cases by Region

The areas with high incidence of varicella are mainly concentrated in East China and Southwest China, especially Jiangsu Province, Zhejiang Province, Anhui Province, Fujian Province, Jiangxi Province, Shandong Province, Shanghai City and other provinces with high population density and mobility. The incidence rate is relatively low in North China and Northeast China. According to the analysis, the high incidence rate of varicella may be caused by the high population density, good economic development and frequent population migration in this area (Fig 6).

### 3.4. The Impact of Time Period on Chickenpox Infection

Figure 7 shows that the incidence of varicella in different seasons has obvious seasonality, with 1 to 2 peaks every year, of which the peak of incidence rate in winter and summer is the largest.;

February to March and August to September are the two peak periods of chickenpox transmission. These two periods are during the winter and summer vacations of the school, and there are few opportunities to interact with susceptible populations.



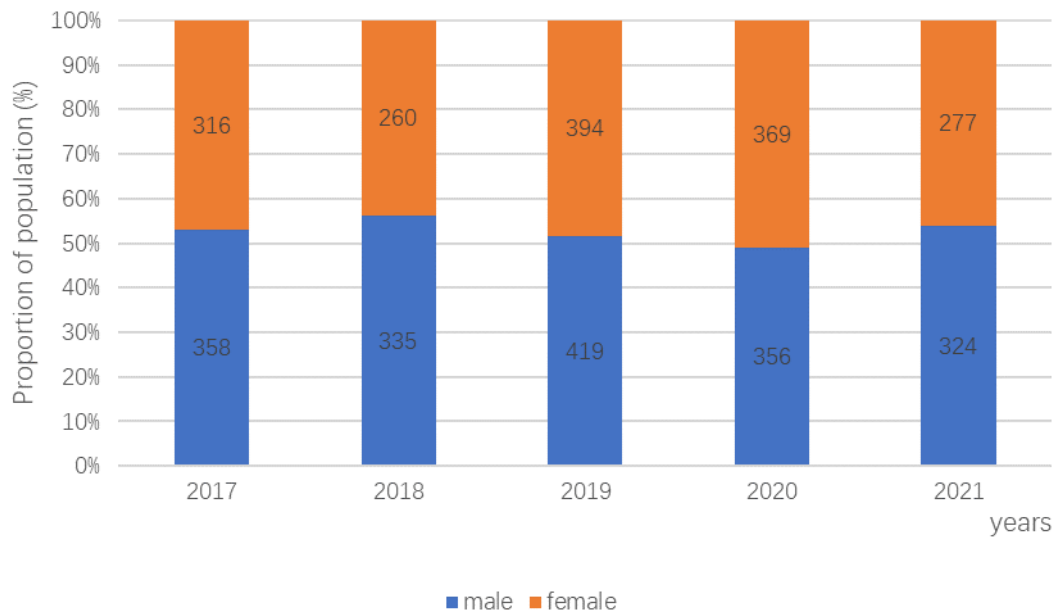
**Fig. 7** The virus occurs in monthly cases

Table 4 shows the relationship between public health and chickenpox in Heilongjiang, and it can be found that with the increase of health events, more people will suffer from chickenpox. This indicates that public health is one of the more important factors in the spread of chickenpox, as it can easily increase the number of patients. It also indicates the need to strengthen health education and management in areas with relatively low socio-economic levels. Because children have poor prevention awareness, it is easy to cause large-scale outbreaks of chickenpox among students.

**Table 4.** Comparison between health events and the number of chickenpox infections

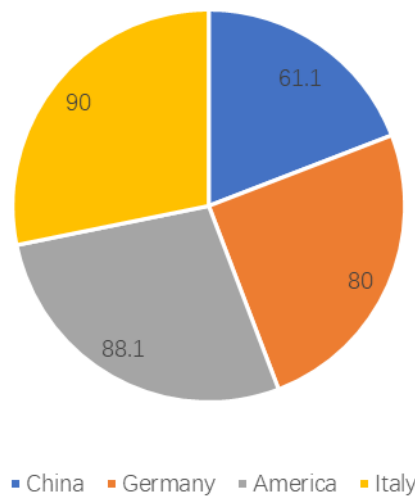
Time (year)	Public health emergencies	
	Number of events (examples)	Number of cases
2014	3	63
2015	2	48
2016	1	26
2017	3	97
2018	5	99
2019	11	260
2020	5	128
2021	2	48

Through the analysis of the data in Figure 8, it is found that the number of men suffering from chickenpox is always higher than that of girls, which means that boys have a higher probability of being spread.



**Fig. 8** Comparison of cases of chickenpox infection between men and women from 2017 to 2021

Vaccination rate (%)



**Fig. 9** Vaccination rates in various countries

Comparing China with other developed countries, it can be found that the vaccination rate in developed countries is much higher than that in China. This also means that the Chinese people have a high incidence rate and mortality of varicella. At the same time, due to China's large population base, the probability of people suffering from chickenpox will further increase. This leads to insufficient supply of chickenpox vaccines in China to meet the demand rate (Fig 9).

#### 4. Conclusion

It is undeniable that due to the limited amount of data, in addition to these factors, there are also other factors in the model that cause some errors in the obtained data, and the sample cannot judge the impact of all factors, which may lead to differences and affect the accuracy of the results. However, this study still has many advantages and value. Firstly, the study used graphics to analyze a large number of influencing factors. This makes all factors more intuitive and reliable. Secondly, it has a

certain positive impact on the prevention of chickenpox. In addition to well-known influencing factors such as vaccination and population mobility, there are also many factors that need to be observed, such as climate change and public health. If further medical investigation is conducted on these factors, it means that they can be inspired in future research on chickenpox prevention. Once these factors are discovered to have an impact on the spread of chickenpox, it can help us better identify and prevent the spread of chickenpox.

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