Epidemiological characteristics of varicella in Chongqing, China, 2014–2021

Yong-Jiao Hu1, Qing Wang2, Mu-Nan Zhang1, Xin Zeng1, Quan-Hong Lu1, Zheng Zhang1, Ping Cheng1, Jing Deng1

1School of Public Health, Chongqing Medical University, Chongqing 400016, China. 2Institute of Immunization Program, Chongqing Center for Disease Control and Prevention, Chongqing 400042, China.

Abstract

Background: To analyze the epidemiological characteristics of varicella epidemics in Chongqing Municipality from 2014 to 2021, and to provide a scientific basis for the formulation of varicella prevention and control measures. Methods: Data on the incidence of varicella outbreaks and vaccination data in Chongqing from 2014 to 2021 were collected through the China Disease Control and Prevention Information System and statistically analyzed using descriptive epidemiological methods. Results: From 2014 to 2021, 213,715 cases of varicella were reported in Chongqing Municipality, with an average annual incidence rate of 86.26/100,000, with a statistically significant difference ($\chi^2 = 24,972.069, P < 0.001$); varicella incidence is seasonal, with peaks in May/June and October/December each year, presenting a “double-peak distribution”. The average annual incidence rate of varicella in municipal districts was 90.74/100,000, which was higher than that of counties 69.62/100,000 and autonomous counties 84.04/100,000; the average annual incidence rate of varicella in males was 89.37/100,000, and in females, 82.22/100,000, with the difference not being statistically significant; the age of onset of the disease was mainly in the group of people under 15 years of age, with a total of 190,021 cases reported (88.9%), with 5–9 years old (35.7%) as the high incidence age group. The incidence occupation was dominated by students in 133,733 cases (62.6%). Conclusion: The overall varicella epidemic in Chongqing is on the rise, and has obvious seasonal, regional and population distribution characteristics. The prevention and control of varicella epidemic should be strengthened, the publicity of varicella vaccine should be increased, and it is recommended that varicella vaccine should be included in the national immunization program.

Keywords: varicella; epidemiologic characteristics; vaccination; preventive and control measures
Introduction

Varicella is a common acute respiratory infectious disease caused by a primary infection with the varicella zoster virus (VZV). VZV belongs to the herpesviridae family, subfamily α-herpesviruses, double-stranded DNA viruses with capsular membranes. It is a highly infectious herpesvirus, and the human being is the only host of VZV. It is a highly contagious herpesvirus, and humans are the only hosts of VZV, with a global prevalence of > 90%. The infection often manifests as varicella in children. After varicella is cured, VZV can remain latent for a long period of time in the sensory ganglia of the host, and when the body is immunocompromised, the virus can replicate along the axon of sensory nerves downstream and into the skin in the areas innervated by the nerves, leading to secondary or multiple infections, causing herpes zoster, which leads to damage to neurons and endings and usually remains accompanied by the same herpes virus after recovery. Damage to neurons and endings usually remains associated with long-term neuropathic pain after healing [1].

VZV is mainly transmitted through respiratory droplets and direct contact, and after infection, symptoms such as mottled rash, blisters, high fever, and malaise can appear, causing varicella, which is a common acute and highly infectious disease in childhood. It is a common, acute, and highly infectious disease in childhood. In severe cases, it can be complicated by pneumonia and encephalitis [2]. The incidence of complications of encephalitis in adults with varicella is seven times higher than in children, and the incidence of complications of pneumonia can be 20% to 30%, which can lead to death in severe cases [3]. Varicella can occur throughout the year, mainly in childcare institutions, schools and other places where people are concentrated outbreaks or epidemics, seriously affecting the physical and mental health of children and adolescents, disrupting the normal order of teaching and learning, and has become a serious public health problem.

In 1952, Weller et al. obtained VZV by cell culture and reported the first successful in vitro proliferation of herpesviruses. In 1971, Japanese scholars Takahashi et al. isolated the parental strain of the Oka vaccine strain (P-Oka strain) from the blister fluid of a 3-year-old child with varicella and cultured it to obtain the VZV attenuated vaccine strain, V-Oka, which has become the standard viral strain for the production of varicella vaccines worldwide [4]. Early clinical studies of effectiveness, including prospective and retrospective cohort studies, case-control studies, and intra-household outbreak investigations, were used in the United States to demonstrate that the vaccine was 100% effective in preventing varicella in this healthy pediatric population [5]. In Finland, a later study using the same methodology showed that the Oka vaccine was > 90% effective [6]. Varicella vaccine (VarV) was first approved for the first time in Germany and Sweden in 1984 [7], followed by Japan and South Korea in 1988, where VarV was officially approved for use in healthy children and adults [8]. In 1995, the U.S. Food and Drug Administration approved the live attenuated varicella vaccine for routine immunization of children 12 to 18 months of age, which was later extended to children 12 months of age to 12 years of age for routine immunization [9]. Currently available varicella vaccines include two live attenuated varicella vaccines each, a combined varicella vaccine, and a shingles vaccine. Since then, vaccination has become the most economical and feasible method to prevent and control varicella. The World Health Organization recommends that children receive two doses of VarV to improve vaccine effectiveness and reduce the incidence of varicella in the whole population. In 1997, VarV was introduced into China as a voluntary vaccine of the second type, and the immunization procedure is to receive the first dose at the age of 18 months and the second dose at 4 years of age. In some regions of China, the VarV vaccination strategy has been adjusted to two doses and included in the immunization program [10–12], but at present, the varicella vaccine has not been included in the immunization program in Chongqing Municipality, and it is still necessary to be vaccinated voluntarily at one’s own expense.

In recent years, outbreaks caused by varicella have received increasing attention from society. However, at present, only a few regions in China have included varicella into local statutory infectious diseases for monitoring and management. For example, Beijing [13] (2007), Tianjin [14] (2007), Shandong [15] (2011), Ningbo [16] (2012), Chongqing [17] (2014), and Jiangsu [18] (2017) have successively issued notifications, technical specifications, and/or surveillance programs to include varicella as a local key surveillance disease and to report and manage it according to the national statutory category C infectious diseases, with different sensitivities of varicella reporting in different places.

The widespread use of the varicella vaccine has dramatically reduced the incidence of the disease in the whole population, but outbreaks still occur frequently in schools with high vaccination rates, and varicella outbreaks rank highly among the causes of school infectious disease outbreaks in public health [19]. In recent years, there have been more studies on varicella epidemiologic characteristics in other provinces and municipalities in China, while fewer studies have been conducted on varicella in Chongqing Municipality. The reported varicella cases in Chongqing Municipality from 2014 to 2021 are now analyzed to understand the epidemiological characteristics and epidemiological trends of varicella in Chongqing Municipality, which will provide scientific reference for further controlling the incidence of varicella, stopping the spread of varicella epidemics, sustaining the improvement of varicella epidemic prevention and control, and reducing the varicella disease burden.

Materials and methods

Material sources

Varicella incidence data for Chongqing, 2014–2021, were obtained from the Infectious Disease Reporting Information Management System in the China Information System for Disease Control and Prevention; varicella vaccination information was obtained from the Chongqing Municipal Immunization Planning Information Management System. Population data were obtained from the Chongqing Statistical Yearbook from the Chongqing Municipal Bureau of Statistics.

Case definition

Varicella cases in this paper refer to clinicians in medical institutions based on the following diagnosis of clinically diagnosed varicella cases or laboratory-confirmed varicella cases: (1) within 14 days of close contact with the population, a history of varicella cases appears; (2) the rash is initially a red macular rash, itchy, and then developed into maculopapular rash, the surface of the formation of blisters with a diameter of 1-4 mm, blisters after a few hours from the transparent to the turbid, the rash appeared successively in batches. Therefore, the same site can be seen in different parts of the rash, and the trunk is the most visible; 1 week after the scabs fall off, they generally do not leave traces; (3) the use of enzyme-linked immunosorbent assays for the detection of varicella cases in the acute phase of the serum VZV-IgM antibody positive, or the recovery phase of the serum VZV-IgG antibody titer than the acute phase was ≥ 4 times higher, or the acute phase of the IgG antibody is negative and the recovery phase is positive.

Statistical methods

Descriptive epidemiological methods were used to analyze the trend of varicella incidence rate and the distribution pattern of the incidence time, area, and population in Chongqing Municipality from 2014 to 2021, using WPS Form 2022 version software to screen and organize the data of varicella infectious diseases and SPSS 26.0 software to conduct the χ² test analysis. The level of the test was taken to be α = 0.05. Each district and county’s varicella incidence rate was spatially mapped using ArcGIS 10.2 software.
**Results**

**Epidemiologic profile**

From 2014 to 2021, a total of 213,715 cases of varicella were reported in Chongqing Municipality, with the ratio of clinically diagnosed cases, confirmed cases, and suspected cases being 974:4:22 and the average annual incidence rate being 86.26/100,000, with the number of incidence cases rising from 11,950 cases in 2014 to 32,164 cases in 2021.

**Epidemiological characteristics**

**Time distribution.** The incidence rate of varicella in Chongqing Municipality increased year by year from 2014 to 2021 and continued to remain high after a small trough in 2020. The number of varicella cases (incidence rate) from 2014 to 2021 was: 11,950 cases (39.95/100,000), 18,474 cases (61.24/100,000), 19,177 cases (62.91/100,000), 26,348 cases (85.68/100,000), 37,344 cases (120.39/100,000), 42,013 cases (134.47/100,000), 26,245 cases (81.88/100,000), and 32,164 cases (100.12/100,000). The average annual reported incidence rate was 86.26/100,000, and the difference was statistically significant ($\chi^2 = 24,972.069$, $P < 0.001$). As shown in Table 1.

Varicella cases were reported in all months of the year from 2014 to 2021 in Chongqing, with an overall bimodal distribution, and the seasonal distribution characteristics of varicella incidence were basically similar each year. The main peak of varicella incidence was October–December, and the secondary peak was May–June, with the number of reported cases accounting for 42.7% (91,304) and 24.5% (52,493) of the total number of reported cases, respectively. As shown in Figure 1.

**Gender distribution.** From 2014 to 2021, the city reported 112,375 varicella cases in males and 101,340 cases in females, and the number of reported cases in males was higher than that in females in all years. The average incidence rates of males and females were 89.37/100,000 and 82.22/100,000, respectively, with a ratio of 1.091, and the difference was not statistically significant ($\chi^2 = 13.785$, $P > 0.05$). As shown in Table 2.

**Age distribution.** Of the 213,715 cases of varicella reported in 2014–2021, the minimum age of onset was 1 day and the maximum was 95 years old, and the incidence of the disease was mainly distributed in the population under the age of 15, with a total of 190,021 cases reported, accounting for 88.9% of the total number of cases. 0–4 years old, 5–9 years old, 10–14 years old, 15–19 years old, and 20–24 years old, 25–29 years old, and ≥ 30 years old cases were 34,429 cases (16.1%), 76,247 cases (35.7%), 56,419 cases (26.4%), 22,926 cases (10.7%), 7,474 cases (3.5%), 7,238 cases (3.4%), and 8,982 cases (4.2%), respectively. The average annual incidence rates for each age group were 256.12/100,000, 554.15/100,000, 434.14/100,000, 139.8/100,000, 42.43/100,000, 522.3/100,000, and 5.71/100,000, respectively. As shown in Figure 2.

**Occupational distribution.** Various types of occupations have varicella incidence, the city in 2014–2021 varicella reported cases, students 133,733 cases (62.6%), diaspores 17,963 cases (8.4%), kindergartens and nursery children 39,274 cases (18.4%), housework and working for work 6,584 cases (3.1%), workers 3,020 cases (1.4%), farmers 3,501 (1.6%), and 9,640 cases (4.5%) in other occupations, with students being the main incidence group in all years, followed by children in kindergartens and nurseries or children living in the diaspora. As shown in Figure 3.

**Regional distribution.** Various districts and counties in Chongqing reported varicella cases every year from 2014 to 2021, with an average annual incidence rate of 28.85/100,000 to 1,546,900 per 100,000, with 26 districts, 8 counties, and 4 autonomous counties having an average annual incidence rate of 90.74/100,000, 69.62/100,000, and 840,400 per 100,000, respectively. The top three average annual incidence rates were in Yubei District (1,546,900/100,000), Liangqing District (1,488,500/100,000), and Nanan District (1,408,500/100,000), while the lowest rates were in Fengdu County (288,500/100,000), Fuling District (314,000/100,000), and Zhongxian County (455,400/100,000). The highest reported incidence rate in 2014 was in Liangqing District (199.68/100,000), Liangqing District 246.38/100,000 in 2015, Nanan District 154.37/100,000 in 2016, Xiusuan Tuja and Miao Autonomous County 1,754,400/100,000 in 2017, Yubei District 290.85/100,000 in 2018, Yubei District 2,648,100/100,000 in 2019, Chengkou County 204.05/100,000, and Bishan County 184.73/100,000 in 2021. As shown in Figures 4 and Figures 5.

### Table 1: The incidence of varicella in Chongqing from 2014 to 2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of people (/10,000)</th>
<th>Number of cases</th>
<th>Incidence (/100,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>3016.55</td>
<td>11950</td>
<td>39.95</td>
</tr>
<tr>
<td>2015</td>
<td>3048.43</td>
<td>18474</td>
<td>61.24</td>
</tr>
<tr>
<td>2016</td>
<td>3075.16</td>
<td>19177</td>
<td>62.91</td>
</tr>
<tr>
<td>2017</td>
<td>3101.79</td>
<td>26348</td>
<td>85.68</td>
</tr>
<tr>
<td>2018</td>
<td>3124.32</td>
<td>37344</td>
<td>120.39</td>
</tr>
<tr>
<td>2019</td>
<td>3205.42</td>
<td>42013</td>
<td>134.47</td>
</tr>
<tr>
<td>2020</td>
<td>3212.43</td>
<td>26245</td>
<td>81.88</td>
</tr>
<tr>
<td>2021</td>
<td>3216.43</td>
<td>32164</td>
<td>100.12</td>
</tr>
</tbody>
</table>

Figure 1: Monthly distribution of varicella cases in Chongqing from 2014–2021
Table 2 Sex distribution of varicella in Chongqing from 2014–2021

<table>
<thead>
<tr>
<th>Year</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of cases (per case)</td>
<td>Incidence (/100,000)</td>
</tr>
<tr>
<td>2014</td>
<td>6283</td>
<td>42.54</td>
</tr>
<tr>
<td>2015</td>
<td>9823</td>
<td>64.38</td>
</tr>
<tr>
<td>2016</td>
<td>10138</td>
<td>65.72</td>
</tr>
<tr>
<td>2017</td>
<td>13803</td>
<td>89.00</td>
</tr>
<tr>
<td>2018</td>
<td>19393</td>
<td>124.04</td>
</tr>
<tr>
<td>2019</td>
<td>22127</td>
<td>140.45</td>
</tr>
<tr>
<td>2020</td>
<td>13738</td>
<td>84.79</td>
</tr>
<tr>
<td>2021</td>
<td>17070</td>
<td>105.03</td>
</tr>
<tr>
<td>Total</td>
<td>112375</td>
<td>89.37</td>
</tr>
</tbody>
</table>

Figure 2 Age distribution of varicella incidence in Chongqing from 2014 to 2021

Figure 3 Occupational distribution of reported cases of varicella in Chongqing from 2014 to 2021
Varicella vaccination

The actual number of doses of varicella vaccine in the city of Chongqing from 2014 to 2021 was 2,805,212 doses, and the varicella vaccine 1-dose inoculation rate rose from 56.09% (200,847 doses) in 2014 to 80.51% (306,569 doses) by 2021, and in 2018, Chongqing recommended that children who had been vaccinated with the 1st dose should be vaccinated with the 2nd dose from the age of 4–6 years old, and the varicella vaccine 2-doses increased from 18.94% (67,818 doses) in 2018 to 57.34% (218,354 doses) in 2021, and the varicella vaccination rate increased year by year.

Discussion

The results of this study showed that the incidence of varicella in Chongqing Municipality generally showed an increasing trend from 2014 to 2021, with the reported incidence rate increasing from 39.95/100,000 (11,950 cases) in 2014 to 134.47/100,000 (32,164 cases) in 2019, decreasing to 81.88/100,000 (26,245 cases) in 2020, and then increasing again in 2021 to 100.12/100,000 (32,164 cases), and the incidence rate in 2021 increased 2.51 times compared to 2014. In 2014, the Chongqing Municipal Health and Family Planning Commission issued the Notice on Including Varicella in the City’s Surveillance Diseases to be Reported and Managed in Accordance with Class C Infectious Diseases, which included varicella in Chongqing’s surveillance diseases to be reported and managed in accordance with the national legal Class C infectious diseases, standardized the varicella reporting and improved the sensitivity of varicella monitoring, and thus may have been the main cause of the steep increase in the number of reported varicella incidence in Chongqing in 2015, which was similar to the varicella incidence in Nanjing, Jiangsu Province [20], and Shanghai, China [21]. The sharp decrease in varicella incidence after 2020 may have been due to the reduction in the number of people gathering during the period of novel coronavirus infections and the wearing of face masks, disinfection, and other measures that blocked the varicella outbreak and spread of the
epidemic. The trend of varicella incidence in Chongqing was consistent with that of the provinces, but the average annual reported incidence rate of varicella (86.26/100,000) was significantly higher than that of the whole country (55.05/100,000) [22] and of Qinghai Province (39.79/100,000) [23], Fujian Province (30.65/100,000) [24], Guizhou Province (63.67/100,000) [10], Beijing Municipality (44.87/100,000) [25], etc. This may be related to population density, geographic location, and the fact that the incidence rate of varicella has decreased dramatically, which may be related to population density, geographic location, and climatic conditions.

The annual incidence of varicella in Chongqing is characterized by a distinct seasonal pattern, mainly in summer and winter, with a double-peak distribution in May-June and November-December, which is different from the epidemiological characteristics of "high in winter and spring" [26] as mentioned in Infectious Diseases (Lan-Juan Li and Hong Ren, 2013) and earlier literature reports. This may be related to the scarcity of earlier surveillance data, or it may be due to improved teaching conditions and the widespread use of equipment such as air conditioning and refrigeration, which in turn reduce indoor air flow. Combined with the main incidence of varicella population, the double peak period is students, kindergarten, and nursery children in the school learning activities during the period. The people gathered and made frequent contact, increasing the risk of varicella virus infection and transmission [20], and the winter and spring climate of the temperate zone are conducive to the proliferation and spread of varicella virus. The months of low peak incidence coincide with the time when students are on summer and winter vacations, which is related to the fact that varicella is generally transmitted by respiratory droplets, contact with fresh herpes fluid, or mucosal secretions of patients with VZV, and that crowds congregate during the school season and are relatively dispersed during summer and winter vacations.

The number of reported cases of varicella in Chongqing from 2014 to 2021 was higher in males than in females, with an average annual incidence ratio of 1.11:1. The incidence of the disease was mainly distributed in the population younger than 15 years of age, which accounted for 88.9% of the total number of reported cases of varicella, which corresponds to the main occupational categories of varicella incidence in the above study (students and children in early childhood care). This is similar to Zhengzhou city [12], Shenyang city [27], Qingdao city [28], and other provinces and cities. This may be related to the fact that children and adolescents are active, while males are more physically active and have a wider range of activities compared to females, and at the same time do not pay enough attention to personal hygiene habits, which makes them more likely to come into contact with the source of varicella virus infection.

From the incidence areas in the above study, varicella cases were mainly concentrated in the municipal districts, and the average annual incidence rate in the 26 municipal districts (90.74/100,000) was much higher than the citywide average (84.59/100,000), with Yubei District having the highest average annual incidence rate (154.69/100,000) in the city. The reasons for this may be: on the one hand, the municipal districts are more economically developed than counties or autonomous districts, have a greater flow of people, are more densely populated, and have more congregated places such as schools and other institutions, which increases the chance of spreading varicella outbreaks; on the other hand, the municipal districts have more healthcare resources and more medical resources, which makes the surveillance of varicella disease more sensitive. With the acceleration of urbanization, people have been gathering in the city center for the convenience of schooling, medical care, and work. There is a net outflow of population, and the incidence of varicella in counties and autonomous districts is relatively low.

With the effective control of measles, cerebral B, hepatitis B, and other diseases through planned immunization, the incidence of varicella is at the top of the list of statutory infectious diseases, and there is no specific drug against the varicella virus, so varicella vaccination is the most effective preventive and control measure. China introduced the varicella vaccine in 1997, but to date only a very few provinces have included the varicella vaccine in their immunization schedules, and in most areas, it is still provided as a non-immunization schedule vaccine to school-age children on a voluntary, self-funded basis. Varicella vaccination mainly has two vaccination strategies, 1-dose and 2-dose, and a study analysis showed that the protective efficacy of 1-dose was 86.3% (85.3%–87.3%), and the protective efficacy of 2-dose varicella vaccine was 97.3% (97.9%–97.6%) [29]. In Chongqing Municipality, self-funded vaccination with 1 dose of varicella vaccine was started for school-age children in 2002, and in 2018, it was recommended that children who had been vaccinated with the 1st dose should be vaccinated with the 2nd dose starting from the age of 4–6 years, and the vaccination coverage rate has been increasing year by year. In Taiwan and Macao, China, the varicella vaccine was included in the childhood immunization program in 2004 and 2005, respectively, and 1 dose of the vaccine was administered free of charge to children aged 12 months or older [30]. In Hong Kong, varicella vaccine has been included in the childhood immunization program since 2014, and two doses are recommended [31]. Thirteen provinces in China, including Shandong Province, Beijing City, and Tianjin City, have also included varicella vaccine in their immunization programs [32], and varicella epidemics have all been further controlled. Chongqing has not yet included varicella vaccine into the immunization planning program, the public has low willingness to vaccinate against it, the number of vaccinations for the school-age population is insufficient, the initial vaccination base is small, and a solid immune barrier has not been established to block the epidemic and transmission of varicella, and a higher and more accurate vaccination rate and preventive and control measures are still needed.

In summary, the overall varicella incidence in Chongqing Municipality in 2014–2021, which is on the rise and has obvious seasonal, population, and regional distribution characteristics, should be based on the characteristics of varicella incidence and epidemic to strengthen the monitoring and management of varicella and do a good job of varicella prevention and control of the key populations and places in a timely manner. Schools should cooperate with the relevant health departments during the peak of the disease to do a good job of prevention and control preparations. It was found that varicella patients reported in a timely manner, and the source of the disease should take strict isolation measures to prevent the further spread of varicella outbreaks. At the same time, using health education publicity day activities to strengthen health education, knowledge popularization of infectious disease prevention and control, and varicella vaccine publicity to strengthen people's understanding of varicella virus and varicella vaccine effectiveness and safety. The implementation of various types of school varicella vaccine checking and replenishment found that the leakage of children in a timely manner to make up for the vaccine, eliminate the immunization gap population, and gradually introduce the varicella vaccine into the immunization program in order to improve the level of immunity of susceptible populations and gradually establish an immune barrier in order to achieve the purpose of preventing and controlling varicella epidemics.

The limitations of this study are that the study data were collected through a passive surveillance system, which may not have included varicella cases that did not seek medical attention, and the 2020–2021 epidemic of novel coronavirus infections may have resulted in late reporting or underreporting. In addition, most varicella cases in this study were clinically diagnosed cases and lacked laboratory diagnosis.

References


Zhao Y, Jiangsu et al. 2022. Vaccine in Disease. 56(8):1118–1126. Available at: https://doi.org/10.16462/j.cnki.zhjbkz.2021.01.009


