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# Epidemiological Characteristics of a Varicella Outbreak in a Primary School and Analysis of Vaccine Protection Efficacy

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**Abstract:** *Objective:* To analyze the epidemiological characteristics of a varicella outbreak in X Primary School in 2024, evaluate the protective efficacy of varicella vaccine, summarize the characteristics of varicella outbreaks, and provide references for the prevention and control of infectious diseases in schools and emergency response. *Methods:* Symptoms of all ill students were analyzed to clarify the epidemiological characteristics, and the Cox regression model was used to analyze the protective efficacy of varicella vaccine. *Results:* The varicella epidemic lasted for one month, involving 3 classes in 2 grades. A total of 16 varicella cases were identified in the school, with an attack rate of 1.78%. The vaccination status of 142 students was analyzed for vaccine protective efficacy. Comparison with unvaccinated students showed that the protective efficacy of 1 dose of varicella vaccine was not significant, while the protective efficacy of 2 doses of varicella vaccine was 82.10%. *Conclusion:* Vaccination with 2 doses of varicella vaccine provides the best protective effect. Timely isolation of ill students after the outbreak can effectively control large-scale varicella outbreaks.

**Keywords:** Primary school students; Varicella; Epidemiological characteristics; Vaccine protective efficacy

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## 1. Introduction

Varicella is a respiratory infectious disease caused by varicella-zoster virus infection. It is highly contagious, mostly occurring in children, and spreads through close contact and aerosols. It is prone to inducing large-scale epidemics, and severe cases can lead to pneumonia and encephalitis, making it one of the important “killers” threatening children’s health [1]. Due to its strong infectivity and wide transmission routes, varicella is likely to cause outbreaks and epidemics in primary schools and kindergartens, seriously endangering children’s health. Therefore, the prevention, control and vaccination of varicella are crucial in primary school health work and important measures to protect primary school students from varicella. Taking the varicella outbreak in X Primary School in 2024 as an example, this study conducted an epidemiological investigation to explore the protective efficacy of varicella vaccine, aiming to provide guidance for varicella vaccination and varicella prevention and control in schools [2].

## 2. Survey objects

### 2.1. Objects and methods

Taking the varicella outbreak that occurred in X Primary School from September to November 2024 as an example, this study analyzed the epidemiological characteristics of the varicella outbreak and the protective efficacy of the vaccine, and put forward suggestions for the prevention and control of varicella epidemics in primary schools. From September to November 2024, some students and faculty members of the school developed varicella-like rashes, mainly presenting as papules, herpes or scabs, and were clinically diagnosed as varicella patients. The varicella patients in the school included breakthrough cases, who had received 1 dose of varicella vaccine. Within 7 days, more than 10 varicella cases were confirmed in the school, which met the characteristics of a varicella outbreak.

### 2.2. Survey methods and content

Referring to the varicella case definition and data from the National Notifiable Infectious Disease Reporting System of China, this study clarified the diagnostic criteria for varicella. Then, combined with data such as the school's morning and noon inspections and registration of absence due to illness, varicella cases in the school were screened. Following the principle of informed consent of patients, staff from the Center for Disease Control and Prevention (CDC) conducted epidemiological investigations through on-site interviews and telephone follow-ups with parents with the cooperation of school teachers. Information such as gender, clinical symptoms, contact history, past varicella history and vaccine vaccination history of students in the classes where varicella cases occurred from September to November 2024 was collected. The varicella vaccine vaccination status of students was verified through the CDC system to gain a more comprehensive understanding of the protective efficacy of the varicella vaccine [3].

### 2.3. Statistical analysis

SPSS 27.0 software was used for statistical analysis of the data. Cox regression analysis was adopted to evaluate the protective efficacy of the varicella vaccine, and the hazard ratio (HR) and its 95% confidence interval (95% CI) were calculated. The vaccine effectiveness (VE) of varicella was calculated using the formula: $VE = (1 – HR) \times 100\%$. The chi-square test ($\chi^2$ test) was used for comparison of rates between groups; the test level was set at $\alpha = 0.05$ (two-tailed).

## 3. Results

### 3.1. Basic information of the school

X Primary School is a public non-residential primary school with a total of 898 students, including 445 males and 453 females; the school has 61 faculty members and 1 part-time school doctor. Each classroom of the school is equipped with an ultraviolet lamp, and ultraviolet disinfection is carried out for 1 hour every day.

### 3.2. Epidemiological characteristics of the varicella outbreak

#### 3.2.1. Epidemic overview

The varicella outbreak started on September 22nd. The index case was a 7-year-old male student from Class 3, Grade 2. On September 22nd, he developed red rashes on the head, neck, chest and back with a normal body

temperature. His parents took him to the hospital on the morning of September 24th. After being diagnosed with varicella, he was placed under home isolation. During the medical visit, it was found that the boy had developed cough symptoms and sought medical treatment 3 weeks earlier. The student had only received 1 dose of varicella vaccine. As of November 15th, 2024, a total of 16 varicella cases were confirmed in X Primary School, with an attack rate of 1.78%, and the duration of the varicella outbreak was as long as 34 days.

### 3.2.2. Clinical characteristics of varicella

This study focused on analyzing the symptoms of 16 confirmed varicella patients in X Primary School and found that they all presented with skin macules or herpes. Among them, 16 patients had herpes on the back, 13 had skin macules or herpes on the head and neck, 13 had herpes on the hands and feet, and 12 had skin macules on the chest [4]. In addition, 10 ill students had fever. No complications occurred in any of the cases, and all patients were classified as mild cases [5].

## 3.3. Analysis of varicella vaccine protection efficacy

The varicella outbreak in X Primary School involved 3 classes with a total of 153 students. After excluding 11 students who had previously contracted varicella, the remaining 142 students were included as research subjects. Comprehensive analysis showed that there were significant differences in the age of patients, the number of vaccine doses received, and the duration since vaccination ($p < 0.05$), which was statistically significant. Cox regression analysis was performed with the vaccine protection period as the dependent variable and the number of doses and duration since vaccination as covariates. After adjusting for factors such as age at vaccination and duration since vaccination, the protective effect of 1 dose of varicella vaccine was not obvious. The risk of contracting varicella in the group that received 2 doses of varicella vaccine was significantly lower than that in the unvaccinated group and the group that received 1 dose of varicella vaccine, as shown in **Table 1**.

**Table 1.** Cox regression analysis of varicella vaccine protection efficacy during the varicella outbreak in x primary school (n = 142)

| Variable | Number of subjects | Number of cases | Attack rate (%) | $\chi^2$ | p | Wald $\chi^2$ | p | HR (95%CI) |
|---|---|---|---|---|---|---|---|---|
| Age (years) | | | | 17.433 | < 0.001 | | | |
| ≤ 7 | 49 | 13 | 26.53 | | | | | 1.000 |
| > 7 | 93 | 3 | 3.23 | | | 14.842 | < 0.001 | 0.035 |
| Vaccination Status | | | | 8.352 | 0.015 | | | |
| Unvaccinated | 31 | 7 | 22.58 | | | | | 1.000 |
| 1 Dose Vaccinated | 29 | 5 | 17.23 | | | 0.031 | 0.861 | 1.000 |
| 2 Doses Vaccinated | 82 | 4 | 4.87 | | | 4.665 | 0.031 | 0.179 |
| Duration Since Vaccination (years) | | | | | | | | |
| ≤ 4 | 55 | 2 | 3.62 | 5.229 | 0.022 | | | 1.000 |
| > 4 | 87 | 14 | 16.08 | | | 0.050 | 0.823 | 0.807 |

## 3.4. Vaccine protection efficacy of emergency vaccination at different time points

This study also focused on classes with more than 2 varicella cases. Taking the occurrence of the first varicella case in the class as the time starting point, emergency vaccination was administered to students without a history of varicella vaccine immunity, and all emergency vaccinations were completed within 3 days, as shown in **Table 2**. Emergency vaccination of varicella vaccine within 3 days for students without a prior history of varicella immunity still achieved a certain protective effect ($p < 0.05$), which was statistically significant.

**Table 2.** Protective efficacy of varicella vaccine by different emergency vaccination time points (%)

| Prior immunity history | Days to emergency vaccination | Secondary cases (Attack Rate, %) | RR (95%CI) | Protection rate (%) |
|---|---|---|---|---|
| None | > 3 | 6 (26.08) | 1 | |
| | ≤ 3 | 1 (3.13) | 0.12 (0.02–0.93) | 88.02 |
| Yes | > 3 | 6 (26.08) | 1 | |
| | ≤ 3 | 1 (3.13) | 0.12 (0.02–0.93) | 88.02 |

## 3.5. Prevention and control measures

Upon receiving the confirmation of the first varicella case, X Primary School promptly reported it to the Center for Disease Control and Prevention (CDC). CDC staff conducted on-site investigations and disposal at the school and quickly formulated a response plan for the varicella outbreak [6]. Firstly, the CDC focused on defining varicella case criteria and rapidly conducted case searches across all grades of X Primary School, especially Grades 1 and 2. This facilitated the prompt identification of classes affected by the outbreak and close contacts, enabling early detection of suspected cases and arrangement for home isolation, thereby achieving the prevention and control goals of "early detection, early isolation, and early treatment" [7]. Secondly, the school arranged for teachers to strengthen morning and noon inspections. Once a student was found absent due to illness, febrile, or presenting with skin macules or herpes, the student was promptly advised to seek medical attention, and parents were notified to closely monitor their child's body temperature and skin changes. Thirdly, under the guidance of the CDC, the school conducted comprehensive disinfection of classrooms with varicella cases and public areas on campus, including disinfectant spraying, increasing the frequency of ultraviolet lamp disinfection, and urging head teachers to enhance classroom ventilation and students to wash their hands frequently [8]. Fourthly, after the detection of varicella cases, the school canceled group activities such as morning exercises and club activities to avoid cross-infection among students. For classes with varicella cases, the school required a 21-day suspension starting from the date of isolation of the last case in the class. Students could only return to school after complete recovery and 3 days of herpes scabbing. Fifthly, X Primary School organized head teachers and teachers of all grades to compile varicella prevention and control brochures and record home isolation guidance videos, which were distributed to parents via WeChat groups and official WeChat accounts. This enhanced parents' and students' understanding of varicella and encouraged their cooperation with the school's prevention and control efforts, helping students recover quickly and return to school smoothly [9].

# 4. Discussion

## 4.1. Formulation of an emergency management plan for varicella outbreaks in schools

Varicella has a relatively long incubation period, strong infectivity, and inconspicuous early symptoms, which are easily mistaken by parents for colds or fevers, leading to rapid transmission. X Primary School lacked sensitivity to this varicella outbreak and failed to detect the index case in a timely manner [10]. Through monitoring and analysis by the CDC, it was inferred that the index case of varicella in X Primary School might have contracted the virus during a hospital visit and continued to attend school unknowingly, resulting in clustered infections within the class and subsequent spread to other classes. Under the guidance of the CDC, X Primary School quickly identified the index case and suspected cases, successfully controlling the varicella epidemic and preventing its spread to other grades and schools. Based on the varicella outbreak in X Primary School, the CDC issued a detailed epidemiological investigation report, concluding that the epidemic was mainly caused by the following factors [11]. Firstly, the student with the index case continued to attend school after developing varicella-related symptoms, and the parents failed to report this to the school in a timely manner, leading to clustered infections within the class. Secondly, the school did not implement timely control measures after detecting 3 varicella cases, and the prevention and control measures were inadequate, resulting in the spread of varicella to other grades in the school.

Therefore, schools should learn from this experience and establish a sound emergency management plan for varicella outbreaks. They should actively promote knowledge about the basic symptoms and prevention of varicella on campus, require parents to pay attention to their children's physical conditions, and urge parents to seek timely medical treatment and arrange home isolation for their children once suspected varicella symptoms appear, as well as report to the school promptly [12]. In addition, after identifying varicella cases, schools should arrange for the isolation of relevant classes immediately and disinfect classrooms and public areas across the campus to avoid secondary generation transmission, block varicella transmission routes, and improve the effectiveness of varicella outbreak prevention and control.

## 4.2. Strengthen varicella vaccination and promotion of prevention and control knowledge

The varicella outbreak in X Primary School was concentrated in Grades 1 and 2. Many students had not been vaccinated against varicella or had only received 1 dose, resulting in insufficient immunity to varicella and making outbreaks more likely. This study found that the protective efficacy of 2 doses of varicella vaccine was significantly higher than that of 1 dose [13]. Varicella vaccine not only prevents the occurrence of varicella but also reduces the severity of the disease, minimizing damage to children's organs and bodily functions. Therefore, schools should strengthen the promotion of varicella vaccination among lower-grade students. Through short videos, animations, and other forms, they should publicize the benefits of varicella vaccination, raise parents' awareness of its importance, and encourage them to take the initiative to have their children receive 2 doses of varicella vaccine. This will enhance children's immunity to varicella and prevent infection [14]. In addition, head teachers of lower grades should conduct surveys on varicella vaccination status, promptly understand the vaccination situation of students in their classes, and urge parents to complete the 2-dose varicella vaccination for their children as soon as possible. Improving vaccination coverage will thereby enhance the protective efficacy of the varicella vaccine [15].

## 5. Conclusion

In summary, vaccination is the best method for preventing varicella. Receiving 2 doses of varicella vaccine provides the optimal protective effect, which can help schools improve the effectiveness of varicella prevention and control and build a strong defense for students' health. Schools should establish a sound varicella prevention and control as well as emergency management mechanism, strengthen morning and noon inspections, enhance classroom ventilation and disinfection, place hand sanitizer and soap in restrooms, and cultivate students' good hygiene habits of frequent handwashing to reduce the risk of varicella transmission. In addition, schools should actively promote knowledge about varicella vaccination and prevention, urge parents to have their children vaccinated in a timely manner, and encourage parents to report their children's health information promptly. By adhering to the principles of "early prevention, early detection, and early treatment," schools can comprehensively improve their ability to prevent and manage public health emergencies.

## Disclosure statement

The author declares no conflict of interest.

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