

OUTBREAK INVESTIGATION

A chickenpox outbreak among international students in a post-secondary institution residence in Ontario, Canada

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ABSTRACT

We report a chickenpox outbreak among international students in Ontario, Canada. This paper highlights the complex challenges of clinical and public health response to outbreak situations. While the incidence of varicella infection has decreased due to widespread vaccination programs in Canada, specific groups, such as international students from areas with lower vaccination rates, remain at risk. The outbreak involved primarily unvaccinated international students residing in a college residence building. Coordinated and prompt contact tracing and administration of post-exposure vaccination were core strategies to control the outbreak. The incident highlighted several challenges that can arise in varicella outbreak management, from determining when and how to order and interpret serological tests, to adjusting isolation measures based on the community's low vaccination rate. Ethical considerations surrounding vaccination policies, particularly for international students came to the forefront. The disparity in access to preventive care highlights broader public health implications and prompts a discussion on equitable vaccination strategies.

KEYWORDS

Varicella, VZV, vaccination, immigrant health, outbreak, chickenpox

INTRODUCTION

Varicella zoster virus (VZV), also known as human herpesvirus 3 (HHV-3), is a highly contagious virus which causes multiple infectious syndromes. The primary infection causes chickenpox (varicella), after which the virus remains dormant in cells of the dorsal root ganglia, and subsequent reactivation of the latent virus causes shingles (zoster), both of which are characterized by a vesicular rash (Dooling *et al.*, 2022). Chickenpox typically presents with a disseminated rash, while the rash from shingles follows a dermatomal distribution. The virus is spread from person-to-person through direct contact with vesicular fluid or aerosolized virus-containing particles from vesicular fluid and possibly respiratory secretions (Gershon *et al.*, 2015). With the introduction of widespread vaccination programs against varicella in many parts of the world, rates of chickenpox have declined globally (Marin *et al.*, 2022). In children, a single dose of varicella vaccine has been shown to be 82% effective

in preventing infection and 92% with two doses (Marin *et al.*, 2016). With the two-dose regimen, vaccine efficacy has been shown to be maintained for at least 10 years (Kuter *et al.*, 2004; Shapiro and Marin, 2022).

In tropical regions (i.e., areas with higher temperature and humidity), chickenpox occurs more often in adulthood compared to temperate climates such as Canada, where seroconversion is often documented in late childhood (Lolekha *et al.*, 2001; Sengupta and Breuer, 2009; Vaidya *et al.*, 2018). In addition to lower vaccination rates in many of these countries, there is lower seroprevalence of immunity in adolescents and young adults (Varela *et al.*, 2019). In a few Canadian studies, the lowest rates of varicella immunity have been documented in young adults from tropical climates (Greenaway *et al.*, 2014; Greenaway *et al.*, 2021). In another study, the highest rates of susceptibility to varicella among refugees in Toronto, Ontario, were in adolescents (Müller *et*

Acknowledgements: The authors thank Razane Diab and Sandra Vesco for their kind assistance in data gathering.

Special thanks also to Linda Watson for reviewing the manuscript draft.

Conflicts of interest: The authors declare no conflicts of interest.

al., 2021). Thus, while widespread vaccination has decreased the burden of chickenpox in Canada, recent immigrants to the country may remain vulnerable to infection. In addition to being at risk for infection, the severity of chickenpox increases with age. The case fatality rate is 1:100,000 for children five to nine years old, while it is 1:5,000 for adults (Marin and Bialek, 2015). Adult immigrants from tropical regions, who were not previously infected with varicella in their home country based on transmission dynamics, are vulnerable to infection when living in Canada.

Here we report an outbreak of chickenpox in a residence building of a post-secondary educational institution in Ontario, Canada, among a group of international students. This outbreak highlights key aspects of outbreak management and important gaps in vaccination coverage within populations in Canada.

OUTBREAK REPORT

In 2023, a local public health agency in Ontario was notified of four probable cases of chickenpox in a post-secondary education institution by a clinician providing healthcare services to the students of the institution. These four individuals presented with a vesicular rash consistent with chickenpox within the span of four days. Other symptoms reported included fever, headache, malaise, chills, and lymphadenopathy. The students were between the ages of 19 and 23. They had no history of prior varicella infection, were not vaccinated against varicella, or their vaccination status was unknown. The four students were living in one of the institution's residence buildings for the previous month since their departure from South Asia. This building was home to more than 400 international students. Three of the reported cases lived on the same floor of the residence building, and two were roommates. The fourth case resided on a separate floor of the residence building.

The local health agency was notified of this potential outbreak six days after the index case presented with symptoms. Diagnostic testing was performed on the same day notification occurred, and the public health agency declared the outbreak two days after notification when the result of varicella serology came back, confirming acute chickenpox infection. The outbreak case definition provided was: clinical evidence of a pruritic rash with rapid evolution from macules to papules, vesicles and crusts (all stages may be simultaneously present) and laboratory confirmation of infection either by a positive serologic test for varicella zoster immunoglobulin M (IgM) antibody, or isolation of VZV from vesicle fluid or swab (i.e., culture) or PCR detection of VZV DNA. The case definition also included clinical evidence of illness in an individual with an epidemiologic link to a laboratory-confirmed case of chickenpox. The index case had reactive VZV IgM and IgG serology indicating acute infection. The second patient had non-reactive IgM and IgG in the context of a positive polymerase chain reaction (PCR) from a lesion swab indicating recent infection. The third patient had non-reactive IgM and reactive IgG with a positive PCR indicating a recent infection. Serologies were not sent for the last patient, but PCR was positive. Once the outbreak was declared, a public health management plan was implemented. Treatment was focused on symptom management. The four patients were isolated to prevent further spread of the disease. A fifth case was identified two days later from the same residence, and they too had a positive PCR test (Figure 1).

Contact tracing was done by creating a line list of cases and identifying all contacts of cases during the period of communicability, which was defined as two days before the onset of the rash until five days after the rash onset. These contacts included first-line contacts (e.g., roommates, those sharing bathrooms and kitchen facilities) and second-line contacts (e.g., classmates, those eating meals together, those

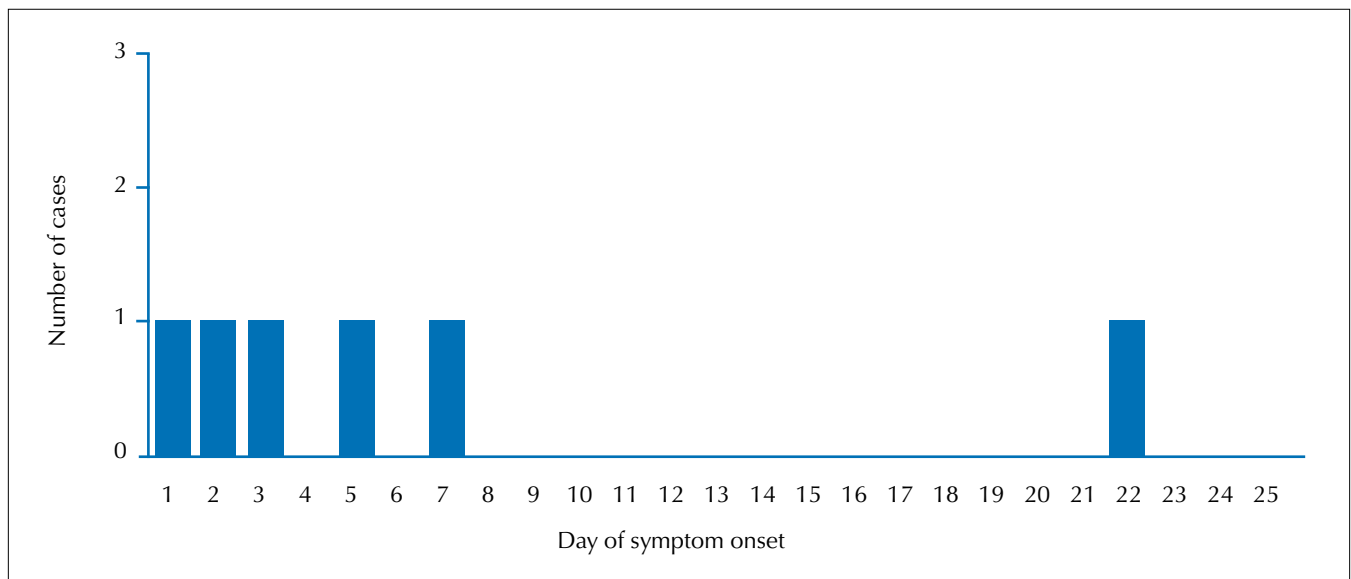


Figure 1: The outbreak's epidemic curve describes the date of the chickenpox symptom onset of the confirmed cases.

undertaking sporting activities together, and visitors and staff of resident facilities). A significant contact was defined as those living in the same dwelling, being indoors with a case for more than one hour, being face-to-face for more than 15 minutes with the case, or having direct contact with a varicella lesion. Contacts who had not previously received two documented doses of varicella vaccine or had a laboratory or self-reported history of chickenpox infection were considered susceptible. Exposed individuals were identified and onsite vaccination was started to provide post-exposure vaccination to identified susceptible contacts.

The duration of the outbreak was 48 days from the onset date. This outbreak required 315 hours of work from public health agency staff, including managers, nurses, clerks, and support staff to manage the outbreak. In this outbreak, more than 250 individuals were assessed, 178 individuals received the varicella vaccine as post-exposure prophylaxis, and no individuals required varicella immune globulin. Of those vaccinated, the majority were living in the residence building. However, some requiring vaccination were also students residing in the community and staff at the institution.

Fifteen days after identifying the fifth case of varicella, the local public health agency received a laboratory report by phone (per the *Health Protection and Promotion Act* in Ontario) of a reactive measles IgM in another student from the same institution. The student was from the same residence building where the chickenpox outbreak occurred. This individual presented with a fever, lymphadenopathy, and a vesicular rash. VZV PCR was later positive, which confirmed this individual to be the sixth case associated with the outbreak. After retrieving the written lab report, the investigation team noted reactive IgM and IgG for measles, in addition to reactive IgM and IgG for mumps and varicella. In follow up, it was found that the serologies were ordered to identify the immune status of the students due to the low vaccination rate in the institution. This individual was part of the outbreak and had already received post-exposure vaccination with a univalent varicella virus vaccine. They became symptomatic within the 7-to-21-days incubation period for varicella (Marin and Bialek, 2015). They presented with vesicular lesions eight days after their vaccination. Given the recent vaccination, genotyping was undertaken, which confirmed an infection with wild-type varicella and not a vaccine-derived strain. As VZV was detected using PCR, no convalescent serologies were ordered. On further history, the patient reported two doses of the MMR vaccine as a child. It was thus determined that the pattern of reactive serologies was likely related to previous vaccination and acute varicella infection.

This outbreak report did not require ethics approval since the operations were within the purview of the Local Public Health Agency's legislated mandate based on the *Health Protection and Promotion Act*, R.S.O. 1990, c. H.7. In addition, the rights and welfare of individuals were protected during the investigation and management of the outbreak.

DISCUSSION

The varicella outbreak reported involving international students at a post-secondary educational institution in Ontario presented a complex clinical and public health challenge. This outbreak highlights an at-risk group of individuals in Canada – international students. The close living conditions of susceptible individuals in this setting is a conducive environment for transmitting communicable diseases, especially varicella, which has a secondary attack rate in susceptible individuals of 61-100% (Marin and Bialek, 2015). This outbreak also highlighted potential challenges in varicella outbreak management, such as the ability to rapidly provide extensive post-exposure vaccination, the flexibility needed to decide on the duration of isolation from school based on a number of at-risk individuals, and the role of and difficulty in interpreting serological tests in outbreak settings.

Clinical and public health management of the outbreak

The public health management of this outbreak had three main components: risk assessment, risk management, and communication. The steps taken for risk assessment are detailed in the outbreak report above. Risk management entailed appropriate treatment of individuals. Antiviral therapies, such as acyclovir, valacyclovir, or famciclovir, are most effective when initiated within 24 hours of rash onset (Gnann, 2007). These therapies are recommended for individuals over 12 years of age, those with complications or those at high risk for complications, and for immunocompromised individuals (Gershon *et al.*, 2015). Complications of chickenpox include secondary bacterial infections, pneumonia, encephalitis, and congenital or perinatal varicella (Marin and Bialek, 2015).

Risk management also includes control of disease transmission. This involves identifying individuals who have come into contact with confirmed cases and assessing their level of contact with the cases, their susceptibility (level of immunity to the disease), and their risk for severe infection. Susceptible contacts received post-exposure prophylaxis with the univalent VZV vaccination, which should be given within three to five days for maximum benefit (Lachiewicz and Srinivas, 2019). Varicella zoster immune globulin should be considered for individuals at increased risk of severe varicella, including pregnant and immunocompromised persons (Lopez and Marin, 2008). The optimal benefit of the immune globulin is achieved if administered within 96 hours of exposure. The number of individuals requiring post-exposure prophylaxis further highlights the high level of non-immunity within this group of international students. Before widespread vaccination programs in Canada, it was estimated that 90% of the population was naturally infected with varicella by 12 years of age (Public Health Agency of Canada, 2023). In Ontario, immunization coverage is tracked for school pupils. In 2021 and 2022, 49.2% of seven-year-olds were vaccinated against varicella, suggesting a decrease from 83.4% in 2018-2019 (Ontario Agency for Health Protection and Promotion, 2023). Though immunity within Canadian populations is relatively

high, this report highlights an important at-risk group especially because they were living in a densely populated setting – college residence buildings.

Another critical aspect of risk management involved determining the duration of isolation. In communities with high immunity levels, such as Canada, children return to school when they are well enough rather than when all lesions are crusted over, based on minimal risk for spread in populations with high vaccination rates (Bridger, 2018). In the United States, the CDC still recommends that children stay home from school until all lesions are crusted over (Kimberlin *et al.*, 2021; 835). In contrast, settings with many unvaccinated individuals or immunocompromised individuals necessitate caution, ensuring isolation until all lesions are crusted over. We adhered to this latter approach, given the high number of susceptible individuals in the institution.

Risk communication included disseminating information to populations at risk. Our assessment found that only students from the institution where the outbreak occurred were at risk. Media communication was coordinated by the institution with the support of the local public health agency to make students and staff aware of the risk, and to encourage them to update their vaccinations. As part of the outbreak debrief, the public health team engaged in open discussions with the institution to minimize future disease outbreaks, such as acquiring vaccination records for incoming students at the start of their training, and facilitating vaccination services for unvaccinated students.

Diagnostic testing and interpretation in outbreak settings

This outbreak emphasized the importance of proper use of diagnostic tests and a process to ensure accurate interpretation of test results. Varicella serology testing was completed in most cases of suspected varicella at the same time that viral swabs for PCR were collected. Acute infection with varicella can be diagnosed clinically and confirmation can be obtained using viral PCR if needed. Serology tests may be supportive, but are generally not recommended for diagnosis of acute infection (Dollard *et al.*, 2022; Kimberlin *et al.*, 2021). Serology can be used for retrospective diagnosis if paired acute and convalescent serologies show a four-fold rise in titers, however, this is not the preferred approach. Additionally, serological testing has not been shown to be adequately sensitive for the determination of varicella vaccination status due to the lower sensitivity (63.5-76%) of IgG tests after vaccination compared to natural infection (Breuer *et al.*, 2008).

Ordering measles and mumps serology to investigate vaccination status during an acute infection without careful consideration was a significant quality care issue. Notably, the individual with reactive IgM for measles was vaccinated against chickenpox as part of the outbreak response, and varicella infection was subsequently confirmed using PCR. False-positive results on IgM measles serology tests have been reported with infection with other viruses, including VZV, parvovirus, HHV-6, rubella, and dengue (Bolotin *et al.*, 2017; Sowers *et al.*, 2022; Thomas *et al.*, 1999; Woods, 2013). Furthermore,

the result was reported without a comprehensive assessment. A positive IgM for measles was initially interpreted as acute measles infection without considering other IgM-positive results for varicella and mumps. This highlights the importance of a multidisciplinary team in managing an outbreak, including laboratory professionals who can advise on appropriate test ordering and interpretation. The oversight was rectified only after a comprehensive evaluation – which incorporated clinical, epidemiological, and laboratory data. The discrepant results and additional resources placed on interpreting unnecessary serological tests clearly exemplified that prioritizing vaccination over serological testing is a preferred approach. In Canada, it is recommended that individuals who have immigrated to the country receive vaccinations when their immunization status is unknown without documenting pre-existing immunity using serological testing as the initial step, due to the low risk of repeat vaccination. Furthermore, during an outbreak, providing vaccination without performing serological testing expedites the management of contacts and decreases the strain placed on public health staff, which is often a concern during an outbreak.

Preventative health disparities

The *Immunization of School Pupils Act* is a piece legislation in Ontario, Canada that requires all children under the age of 18 to be immunized against designated diseases (e.g., measles and varicella) unless a valid exemption exists (*Immunization of School Pupils Act*, 1990). While the act provides a means for domestic students who are not adult learners to have updated vaccination records before enrolling in higher education, most international students are excluded as the act does not apply to post-secondary institutions. This disparity necessitates a broader discussion on ensuring all individuals have equal access to preventative health measures. Previous guidelines for immigrant and refugee health have highlighted the need to provide vaccination to those without immunization records (Pottie *et al.*, 2011). However, this outbreak report highlights that this is still not routinely done. The high number of susceptible students at the institution where the outbreak occurred, many of whom came from regions where varicella vaccination is not universally offered, emphasized the value of synchronized international vaccination strategies (Cai *et al.*, 2014). This outbreak revealed disparities in preventative health among populations in Canada, and highlights the ongoing need to take further actions to protect those populations from communicable diseases. Here we highlight the potential role for better documentation of immunization status of post-secondary students and improved access to vaccinations for those who have not been vaccinated.

There are limitations to our study. First, every outbreak scenario is different, and the recommendations that were used to manage this outbreak may not be appropriate in other scenarios. Furthermore, regional policies may vary on the approach to case management. The approach to diagnostic testing in an outbreak scenario will also vary based on laboratory capacity and test availability. This highlights the importance of a multidisciplinary approach in outbreak

management. Despite these limitations, this outbreak highlights key aspects of outbreak management. Importantly, it demonstrates health disparities within Canada and the vulnerability to varicella infection in international students and those born outside the country. Streamlined and effective chickenpox outbreak management will continue to be important especially given decreasing rates of vaccination among domestic students in conjunction with these vulnerable populations.

Together, the disparity in access to preventive care highlights broader public health implications and prompts a discussion on equitable vaccination strategies.

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