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Hospital-acquired infections and unvaccinated children due to chronic diseases: an investigation of the 2017–2019 measles outbreak in the northern region of Vietnam

Dien M. Tran[1,2†], Thinh Ong[3†], Tung V. Cao[4], Quang Thai Pham[5], Hien Do[6], Phuc H. Phan[7], Marc Choisy[8,9] and Nhung T. H. Pham[10,11*]

Abstract

Background Measles remains a major public health burden worldwide. Parents often hesitate to vaccinate children with chronic diseases. We investigated the association between the percentage of vaccination and chronic diseases and explore hospital infections' role in the 2017–2019 measles outbreak across northern Vietnam provinces.

Methods A total of 2,064 children aged 0–15 years old admitted for measles to the National Children's Hospital during the outbreak were included in the study. Demographic information, clinical characteristics, vaccination statuses and laboratory examination were extracted from electronic medical records, vaccination records, or interviews with parents when other sources were unavailable.

Results The incidence rate that provincial hospitals sent to the National Children's Hospital was proportional to the population density of their provinces of residence. Early nosocomial transmission of measles was observed before community-acquired cases emerged in many provinces. Among patients aged over 18 months, those with chronic diseases had a proportion of vaccination of 9.4%, lower than patients without chronic diseases at 32.4%. Unvaccinated patients had a higher proportion of hospital-acquired infections with aOR = 2.42 (1.65–3.65), $p < 0.001$ relative to vaccinated patients. The proportion of hospital-acquired infections was higher among children with chronic diseases compared to those without, with aOR = 3.81 (2.90–5.02), $p < 0.001$.

Conclusion Measles spread in healthcare settings prior to community cases that occurred in several provinces. We recommend enhancing hospital infection control by increasing staff training and improving early detection and isolation during non-outbreak periods. Measles patients with chronic diseases exhibited lower proportions of vaccination and faced a higher risk of hospital-acquired infections. It is crucial to establish comprehensive vaccination

†Dien M. Tran and Thinh Ong contributed equally to this manuscript.

*Correspondence:
Nhung T. H. Pham
hongnhung.ytcc@gmail.com

Full list of author information is available at the end of the article

guidelines and enhance parental awareness regarding the significance and safety of measles vaccination to protect these vulnerable individuals.

Keywords Measles, Nosocomial transmission, Vaccination, Chronic diseases, Hospital-acquired infection

Introduction

Measles is a highly contagious acute viral infection that can lead to severe morbidity and mortality in children [1]. Despite the availability of effective vaccines, measles continues to be a significant cause of illness and mortality globally, resulting in approximately 100,000 deaths annually [1]. In 2011, the Global Measles and Rubella Strategic Plan was established by the World Health Organization aimed to achieve measles elimination in five out of six World Health Organization regions by the end of 2020. However, no region has been able to achieve or maintain elimination as outlined in the plan [2].

Eliminating measles remains a crucial goal for every country worldwide [3], which requires a combination of multiple measures simultaneously including epidemic control, effective surveillance, and immunization [4]. Measles vaccination has been estimated to have prevented approximately 31.7 million deaths worldwide between 2000 and 2020 [2]. The World Health Organization advises a vaccination coverage of 90–95% is crucial in attaining herd immunity. Despite many efforts in the vaccination programs, measles outbreaks continue to occur at intervals of 2 to 5 years in endemic areas [5]. Countries that previously declared the elimination of measles still experience intermittent outbreaks. For example, although reporting a national vaccination coverage of 94.7%, the United States experienced a resurgence of measles outbreak with a total of 1,282 cases across 31 states and 94 counties in 2019 [1, 6]. Between 2017 and 2019, measles cases hit historic peaks in many European countries, including France, Georgia, Greece, Italy, Romania, Serbia and Ukraine [7]. Pockets of underimmunized communities within populations are often what pose a large risk for outbreaks. Specifically, despite vaccine coverage of approximately 90–95% in the United States, there still could be pockets of very low vaccine coverage. In 2022, both the United States Centers for Disease Control and Prevention and World Health Organization have declared measles to be an "imminent threat" worldwide. This alarming status is attributed to declining vaccination rates and weakened surveillance during the COVID-19 pandemic [8].

Vietnam is a lower middle-income country which implements the WHO's Expanded Program on Immunization. The country added measles-containing vaccines to its routine vaccination schedule in 1982 [9], with the recommendation being to administer a first dose at 9 months of age and a second dose at 18 months of age [10]. Studies have shown that measles vaccine coverage rates in Vietnam are significantly influenced by social factors. These factors include doubts about vaccine safety, lack of trust in public vaccination centers, and concerns about side effects, all contribute to lower participation in child immunization programs among specific groups [11]. Children from ethnic minority groups, lower-educated mothers, and from the poorest households were less likely to receive the measles vaccine. However, a notable proportion of highly educated, wealthy mothers also chose not to vaccinate their children against measles [11]. Major outbreaks continue to occur every 4–5 years, such as outbreaks in 2009, 2013–2014 and 2017–2019. The 2014 outbreak in northern Vietnam recorded 9,577 confirmed cases of measles, with an incidence rate of 116.4 per 1,000,000 population during the outbreak [12]. Many hospitalized children with measles were under 12 months old and not fully vaccinated. Among older children admitted with measles, a large proportion had no vaccination history [13]. Moreover, during extensive community outbreaks, tertiary care hospitals become overwhelmed with a large influx of patients. The overcrowding and compromised infection control measures within the hospital setting pose a clear and significant risk of in-hospital transmission [14]. Nosocomial infections can further exacerbate the scale of epidemics and may lead to an increase in both morbidity and mortality rates.

The period from 2017 to 2019 witnessed a significant rise in measles cases in Vietnam. The National Children's Hospital in Ha Noi is the largest pediatric tertiary referral hospital that received patients from all northern provinces, particularly moderate to severe cases and individuals with congenital or comorbid conditions referred from provincial hospitals. Given the substantial number of cases during the outbreak, the National Children's Hospital faced multiple challenges in terms of providing clinical services while maintaining infection control prevention activities. In this study, we conducted an analysis of the epidemiological and clinical characteristics of all measles patients admitted to the National Children's Hospital during the 2017–2019 outbreak. Our objectives were to explore the spatial and temporal transmission pattern, the association between lack of vaccination and the presence of chronic diseases, as well as to assess the potential role of hospital-acquired infections in measles outbreak spread among northern provinces in Vietnam.

Methods

Data collection

We conducted a retrospective study at the National Children's Hospital in Ha Noi, Vietnam. All patients diagnosed with measles admitted to the Infectious Disease Department and Intensive Care Unit during the 2017–2019 outbreak were included in the study. Demographic information (age, sex, and commune of residence), clinical characteristics (date of onset, date of hospitalization, pneumonia condition, chronic diseases), interventions (oxygen therapy, high-flow oxygen, mechanical ventilation, dialysis, extracorporeal membrane oxygenation support), laboratory examination (IgM, PCR) were extracted from electronic medical records. Data regarding vaccination status were collected from the child's vaccination record on paper form or electronic medical record (for approximately 90% of cases), or interviewing parents if the other sources are not available. The study health record form is included as Supplementary 1.

During the outbreak, a variety of infection control measures were implemented at the National Children's Hospital. All staff members and visiting students were required to be vaccinated against measles. A separate unit was established at the Center of Clinical Medicine for Tropical Diseases in Children to treat measles patients, and an isolated room was set up for measles patients in the intensive care unit. In each chronic disease department (cardiovascular, neurology), separate rooms were designated to isolate suspected cases or treat confirmed measles cases. For patients with severe chronic diseases, separate treatment rooms were arranged in the respective chronic disease departments. Family visits were prohibited, and separate care items and staff were designated. Special requirements for personal protective equipment such as N95 masks and protective clothing were enforced in line with international recommendations for measles. Throughout the epidemic, no cases of measles were detected among the hospital staff.

Definitions

Measles cases were defined as in-patients under 16 years old who exhibited fever, rash, and were confirmed to have measles through positive results from either IgM or PCR tests. The date of onset was determined as the first day the patient presented with rash symptoms.

The patient's vaccination status was categorized as "unvaccinated" if they have not received any vaccine doses, or as "vaccinated" if they had received at least one dose.

Patients were classified as hospital-acquired infections if they met one of the following conditions:

- Patients treated at the hospital and experiencing symptom onset at least 22 days after admission;
- Patients who stayed in the hospital for a minimum of 14 days and developed symptoms within 7 days after discharge;
- Patients admitted to the hospital between 8 and 21 days before symptom onset;
- Patients who were hospitalized and experienced symptom onset within 21 days after discharge.

Severe patients were defined as individuals diagnosed with measles who were presented with pneumonia or bronchitis and required supplemental oxygen therapy. The severity of the condition was categorized into two levels:

- Severity level 1: Patients who required either oxygen therapy or continuous positive airway pressure to manage their respiratory distress.
- Severity level 2: Patients exhibited a more critical condition and received advanced interventions such as high-flow oxygen, mechanical ventilation, dialysis, or extracorporeal membrane oxygenation support.

Chronic diseases were defined as any chronic diseases identified from the electronic medical record of patients. Chronic diseases were classified into:

- Chronic infection: chronic hepatitis B infection, hepatitis C infection, HIV infection, congenital syphilis.
- Cancer: acute lymphoblastic leukemia, neuroblastoma, nephroblastoma, Burkitt lymphoma, osteosarcoma and other cancer diseases.
- Metabolic disorders: beta-ketothiolase deficiency, citrin deficiency, glycogen storage disease, glutaric acidemia type II, isovaleric acidemia, cow milk protein allergy, and other metabolic disorders.
- Cardiovascular system: transposition of great arteries, patent ductus arteriosus, aortic coarctation, ventricular septal defect, tetralogy of Fallot, total anomalous pulmonary venous return and other congenital heart diseases.
- Gastrointestinal system: Crohn's disease, biliary atresia, Hirschsprung's disease, autoimmune hepatitis, cirrhosis, anorectal malformation, megacolon and other congenital gastrointestinal diseases.
- Neurological system: cerebral palsy, mental retardation, epilepsy, ventriculomegaly, craniosynostosis, hydrocephalus and other chronic diseases of the neurological system.
- Autoimmune and immunodeficiency: systemic lupus erythematosus, aplastic anemia, common variable immunodeficiency, Wiskott-Aldrich syndrome and other autoimmune and immunodeficiency diseases.

- Kidney and urology system: congenital nephrotic syndrome, kidney failure, polycystic kidney disease, Bartter syndrome, and other congenital kidney diseases.
- Other chronic diseases: such as thalassemia, eczema, undescended testicle, craniosynostosis, Erb's palsy….

Ethics statement

The study was approved by the Institutional Review Board of the Vietnam National Children's Hospital, which waived the requirement for consent to participate because the analysis was retrospective (Approval reference number: 473/BVNTW-HDDD, IRB identifier: IRB-VN01037/IRB00011976/FWA00028418).

Table 1 Demographic and clinical characteristics of patients ($n=2064$)

	Frequency	Percentage
Year of admission		
2017	127	6.1
2018	627	30.4
2019	1310	63.5
Age (month-old)	9 (6–16)	Median (IQR)
Sex		
Male	1292	62.6
Female	772	37.4
Diagnosis upon admission		
Measles	845	40.9
Bronchopneumonia	846	41.0
Others	373	18.1
Vaccination status		
Unvaccinated	1856	89.9
Vaccinated (any dose)	208	10.1
Severity		
Mild	1215	58.9
Level 1	691	33.5
Level 2	158	7.6
Source of infection		
Community	1273	61.8
National Children's Hospital	547	26.5
Provincial hospitals	241	11.7
Chronic diseases		
No	1782	86.3
Yes	282	13.7
Specific chronic diseases (among $n=282$)		
Cardiovascular system	89	31.6
Gastrointestinal system	88	31.2
Neurological system	69	24.5
Cancer	39	13.8
Metabolic	16	5.7
Kidney and urology system	15	5.3
Autoimmune and immunodeficiency	11	3.9
Chronic infection	11	3.9
Others	56	19.9

Statistical analysis

Categorical data are described using frequency and percentage. The relationships between hospital-acquired infection, vaccination status and presence of chronic diseases were assessed using Chi-square test. We fitted a cubic polynomial to demonstrate how vaccination percentages vary across different age groups. We computed Pearson correlation coefficient to examine the correlation between the incidence rate and population density across all provinces. Multivariable logistic regression was performed on vaccination status, the presence of chronic diseases and age to estimate adjusted odds ratios (OR). All statistical analyses were performed using R Statistical Software (v4.3.2; R Core Team 2021).

Results

Measles outbreak in children

From July 2017 to December 2019, a total of 2,064 children admitted to the hospital were confirmed with measles. Demographic and clinical characteristics of patients were described in Table 1. The first case was a 2-year-old child who was community-acquired infected. The age distribution of children was stable during the outbreak, with approximately half of the children under the age of 9 months (Fig. 1A). The temporal distribution of cases reached a peak in May 2019 for all age groups, except the age group of over 2-years-old which reached its peak sooner, in around March 2019 (Fig. 1B).

During the outbreak, the percentage of patients with severity levels 1 and 2 were 33.4% and 7.7%, respectively. An increasing trend in the percentage of severe patients was observed since December 2017, then remained relatively constant until the end of 2019 (Fig. 2A). The peaks of the temporal distribution of the cases in most provinces were in May 2019, regardless of the source of infection. The peak of patients infected in the community and provincial hospital in Nghe An was reached earlier than the rest, around November 2018 (Fig. 2C). Indeed, measles cases from Nghe An were the highest in November 2018 and decreased in subsequent months (Fig. 4B, C). Early nosocomial transmission of measles was observed before community-acquired cases emerged in provinces including Hung Yen, Ha Nam, Nam Dinh, and Hai Phong. Among measles patients admitted to the National Children's Hospital. The percentage of hospital-acquired infection was higher among unvaccinated patients than vaccinated patients with aOR=2.42 (1.65–3.65), $p<0.001$. The proportion of hospital-acquired infection among measles patients who have chronic diseases was higher than patients without chronic diseases with aOR=3.81 (2.90–5.02), $p<0.001$ (Table 2).

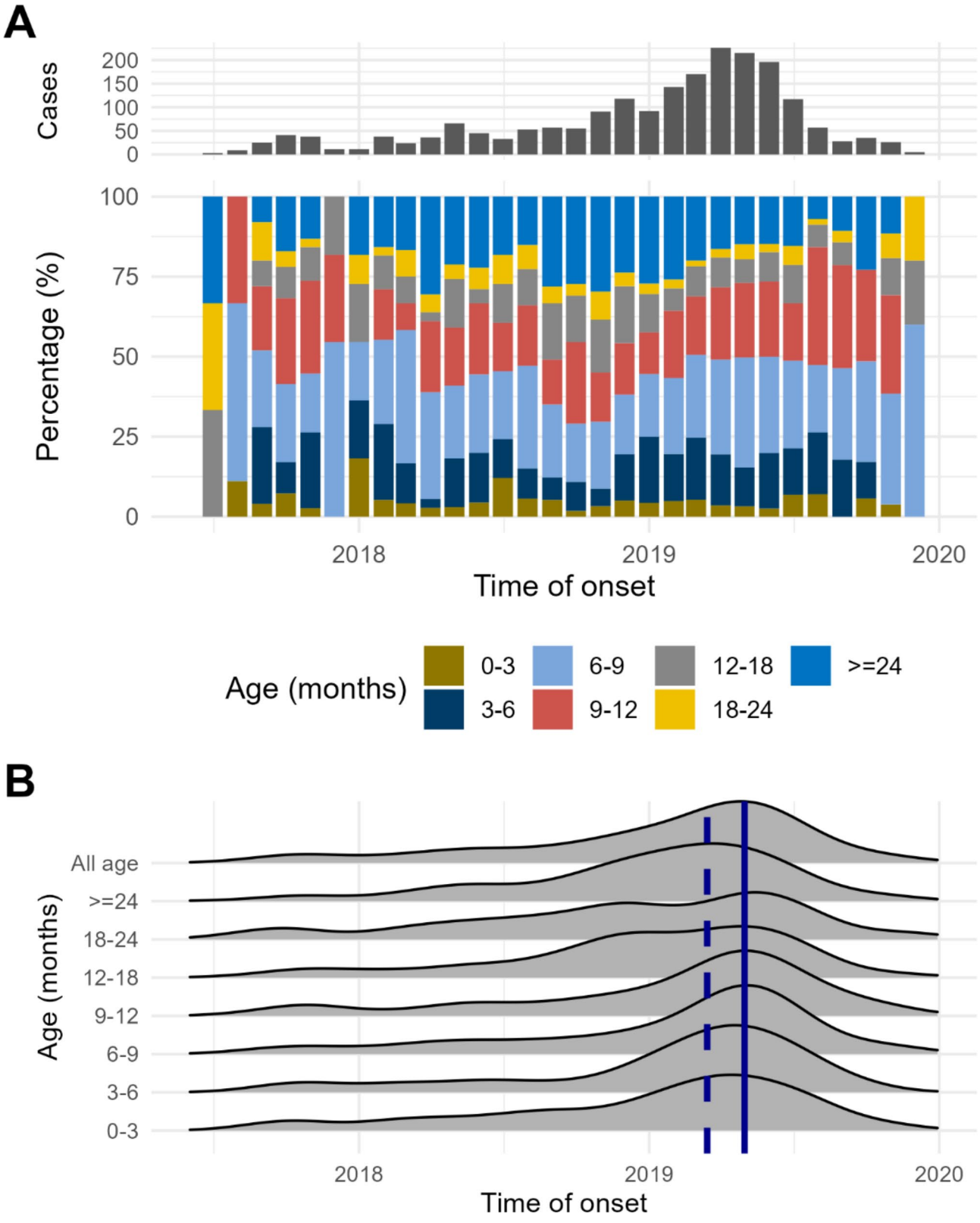

Fig. 1 Age distribution of measles children admitted to National Children's Hospital over the outbreak period. **(A)** The percentage of age groups as a function of time (monthly). **(B)** Temporal distribution of cases in different age groups; dashed line is March 2019 and solid line is May 2019

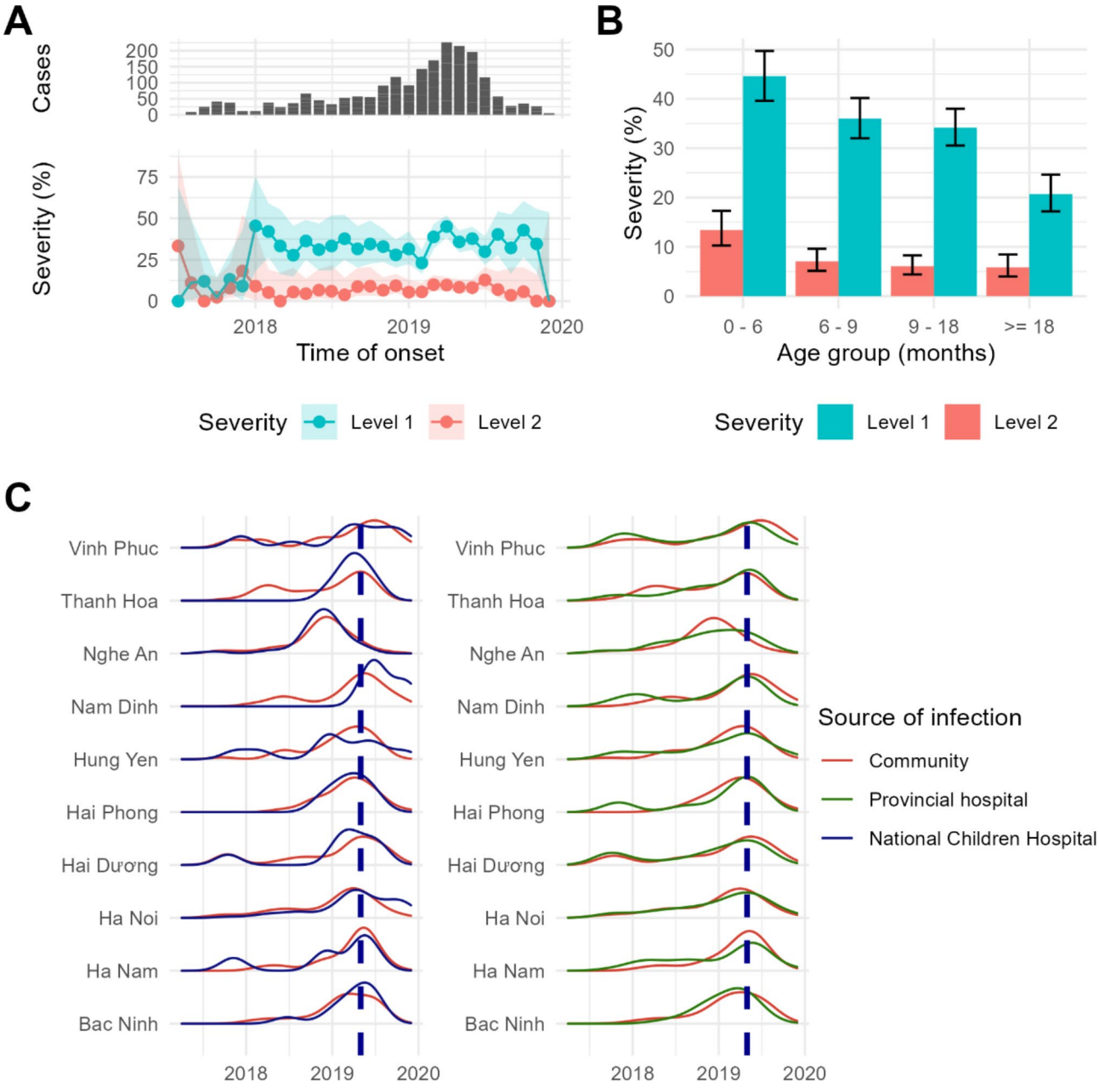

Fig. 2 **(A)** The severity of patients as a function of time. **(B)** Severity of patients categorised by different age groups. **(C)** Temporal distribution of cases of top 10 provinces, categorised by source of infection; dashed line: May 2019

Vaccination status and measles infections among children with chronic diseases

During the first few months of the outbreak, all measles patients were unvaccinated. Beginning from October 2017, some vaccinated children got infected. The percentage of patients who were vaccinated was <30% of the hospitalized cases during the outbreak period (Fig. 3A). The percentage of vaccinated children among the measles patients increases with age until 22 months where it reaches a plateau of about 27% (Fig. 3B). All patients under 6 months were unvaccinated, while a fraction of patients at 6–9-month-old (1.8%), 9-18-month-old (10.1%) and over 18-month-old (27.7%) were vaccinated (Fig. 3C). Lower proportion of vaccination (5.6%) were found in patients with chronic diseases as compared to those without chronic diseases (10.8%). Among patients aged 9 to 18 months, only 8.1% of patients with chronic diseases received vaccination, whereas 10.4% of patients without chronic diseases were vaccinated. Similarly, among patients over 18 months old, the proportion of vaccination was 9.4% for those with chronic diseases,

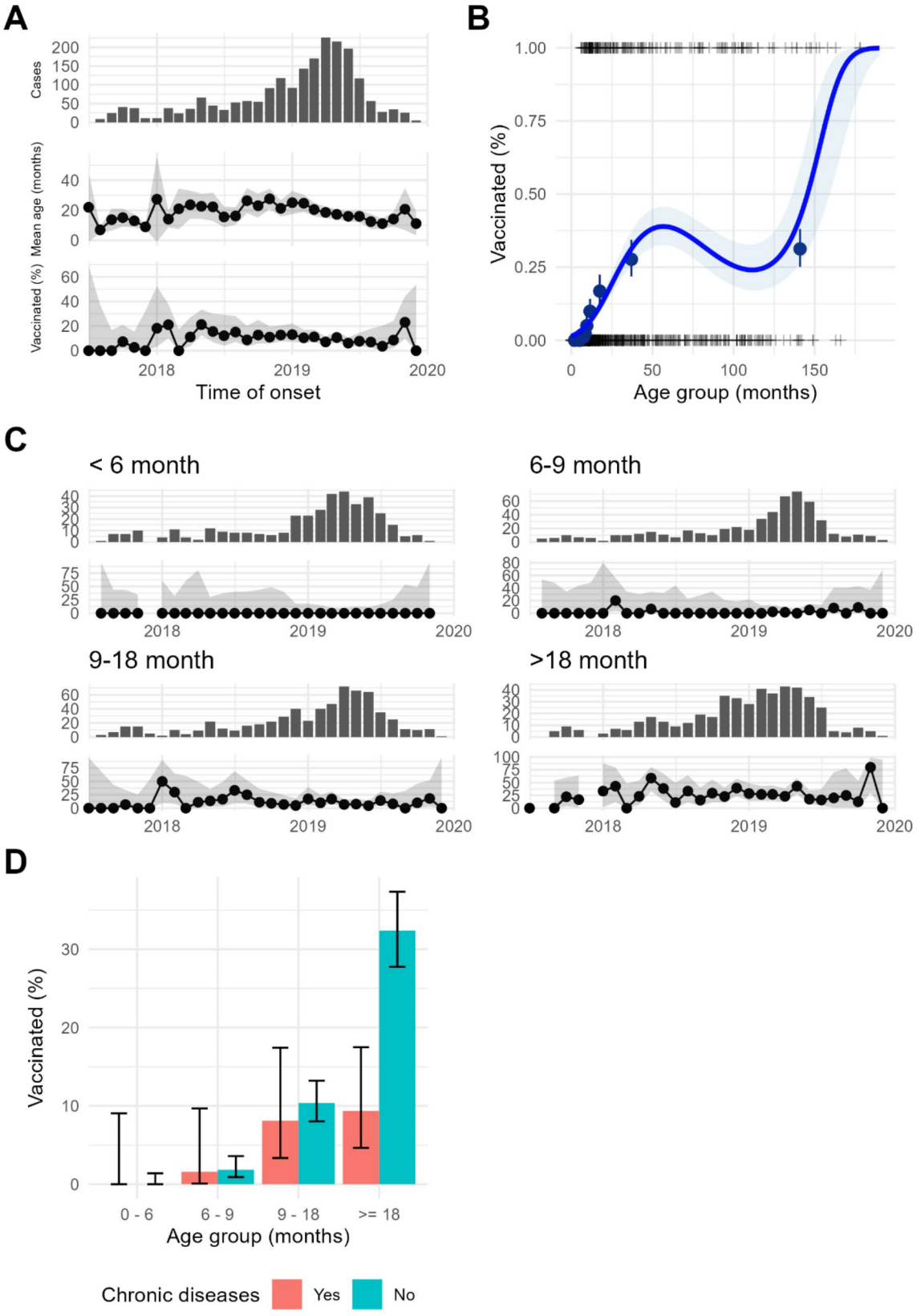

Fig. 3 Vaccination status of measles children. **(A)** The percentage of vaccination among all patients in the National Children's Hospital as a function of time of onset. **(B)** Mean vaccination proportion of decile age groups (dots) with 95% CI plotted together with a cubic logistic regression. **(C)** The percentage of vaccination as a function of time in different age groups. **(D)** Vaccination proportion of different age groups categorised by chronic disease status

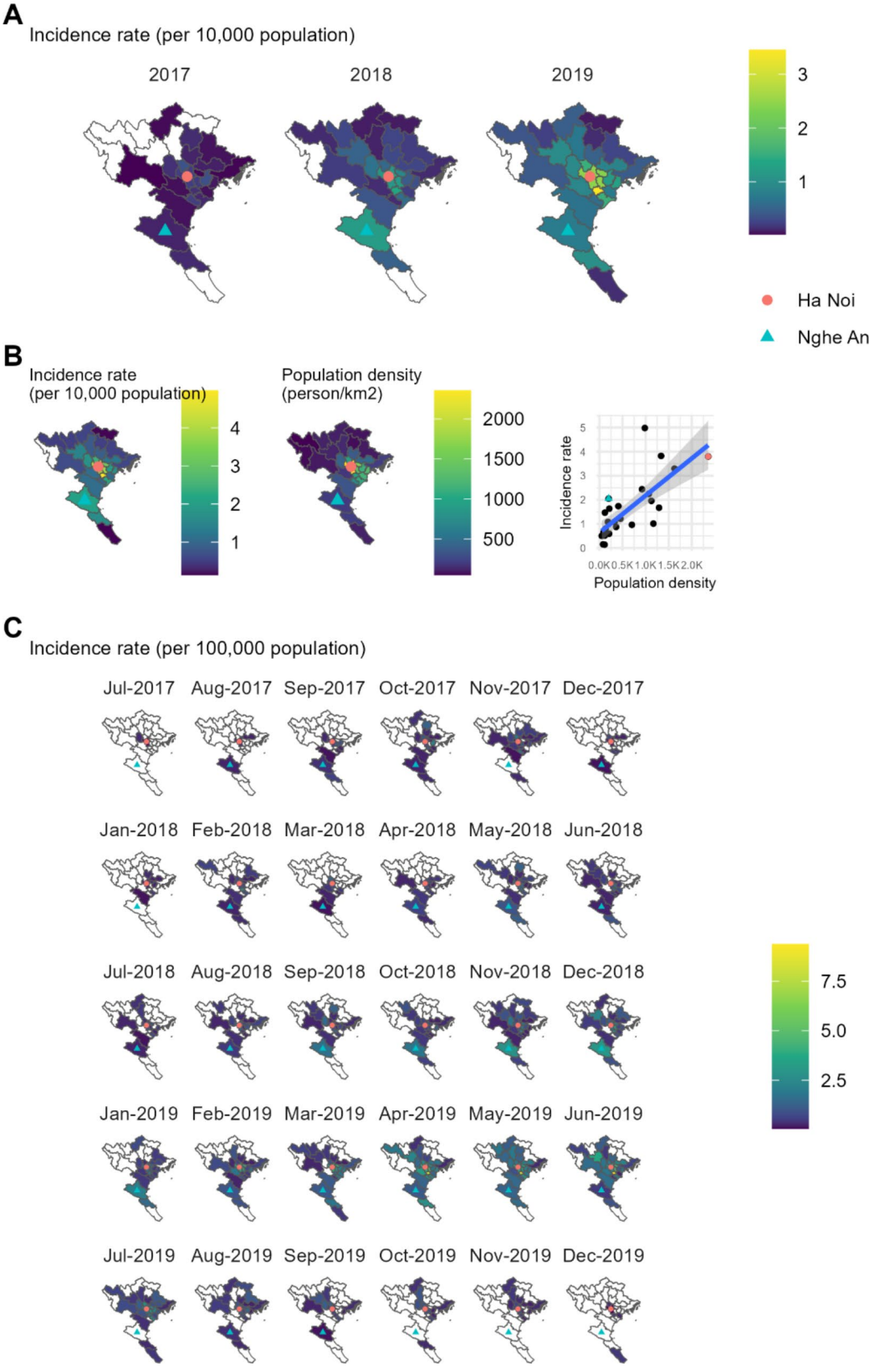

Fig. 4 **(A)** Incidence rate (per 10,000 population) of northern provinces admitted to the National Children's Hospital. **(B)** The relationship between incidence rate and population density. **(C)** Spatial distribution of patients admitted to the National Children's Hospital in 2017, 2018 and 2019

Table 2 Comparison of patients' characteristics according to source of infection

Characteristic	Hospital *N* = 788	Community *N* = 1,273	OR	Adjusted OR
Vaccination				
Vaccinated	36 (17.1%)	174 (82.9%)		
Unvaccinated	752 (40.6%)	1,099 (59.4%)	3.31 (2.31–4.86)	2.42 (1.65–3.65)
Chronic diseases				
No	607 (34.1%)	1,173 (65.9%)		
Yes	181 (64.4%)	100 (35.6%)	3.50 (2.69–4.56)	3.81 (2.90–5.02)

much lower than the proportion of vaccination of 32.3% observed in patients without chronic diseases (Fig. 3D).

Incidence rate and population density

The incidence rates of measles patients from provinces across the north sending to the National Children's Hospital in each year were shown in Fig. 4A. The incidence rate of provincial hospitals sent to the National Children's Hospital were proportional to the population density of corresponding provinces with a correlation coefficient of 0.76 ($p<0.001$) (Fig. 4B). Beginning from August 2017, there were 2 clusters (Ha Noi and Nghe An) spreading the disease to nearby provinces. When the epidemic curve flattened at the end of 2017, almost no cases were sent from provinces other than Ha Noi and Nghe An (Fig. 4C). At the end of 2018, almost all provinces in northern Vietnam sent measles patients to the National Children's Hospital (Fig. 4C). In the second half of 2019, fewer children from nearby provinces were admitted to the hospital, and the outbreak subsided by September 2019, with only sporadic cases primarily originating from Ha Noi and Nghe An (Fig. 4C).

Disscussion

Despite achieving high measles vaccination coverage of over 95% for children who received the first dose consistently since 2004, Vietnam continues to experience endemic measles outbreaks. The country has encountered several significant outbreaks, including those in 2006, 2009, 2014, and the most recent one spanning from 2017 to 2019. The National Children's Hospital is the largest pediatric tertiary referral hospital responsible for treating almost all moderate to severe cases in northern Vietnam. This study analyzes all measles cases admitted to National Children's Hospital throughout the duration of the most recent national-scale measles outbreak.

During the outbreak, approximately half of the children hospitalized for measles at the National Children's Hospital were under 9 months old, and this percentage remained consistent throughout the outbreak. This pattern aligns with studies that reported measles outbreaks in Southern China from 2009 to 2016 [15] and the United States in 2018–2019 [16]. The reason behind this trend may be attributed to the immunization system's design, which considers these infants too young to receive routine immunization. In Vietnam, the recommended schedule for measles vaccination involves administering a first dose at 9 months old and a second dose at 18 months old. Maternal immunity against measles diminishes rapidly, with levels generally falling below the protective threshold by 3 months of age [17], and infants aged 0 to 8 months have been identified as a high transmissibility group in previous studies [15]. However, lowering the minimum age for the first measles vaccination to 6 months remains a topic of controversy. Studies have shown that receiving measles vaccination before 9 months of age may result in lower antibody titers and reduced vaccine effectiveness [18]. In addition, among children aged over 2 years, who generally receive two doses of the measles vaccine, there was an earlier peak in measles cases compared to all other age groups. Given the higher vaccination coverage in this older age cohort, the proportion of susceptible individuals is lower than in other groups, potentially leading to an earlier end to the outbreak compared to younger children. First-dose measles-containing vaccine coverage globally has remained at 84–85% for over a decade [19], which reflected in our study's early low vaccination rates. In Hanoi, parents often choose to wait until 12 months for the measles-rubella vaccine at private vaccination centers, rather than the 9-month monovalent measles vaccine in the Expanded Program on Immunization, contributing to a larger vaccination gap [20]. Amidst the 2018 outbreak, the Ministry of Health of Vietnam launched a measles-rubella vaccination campaign for 4.2 million children aged 1 to 5 years in high-risk areas across 57 cities and provinces [21], which likely contributed to the observed increase in vaccination rates.

In contrast to the 2014 outbreak which only lasted for 1 year, the 2017–2019 outbreak lasted for 3 years and had caused hospital overloading which led to a mortality rate of 10% among hospitalized patients, while the typical mortality rate of measles hospitalizations is reported as 2–3% [22, 23]. We found that once the national pediatric hospital started to receive a lot of patients from Ha Noi and Nghe An, which means the outbreaks have occurred in these two provinces, it quickly spread to neighboring areas. The outbreak also came to an end when cases

sent from these two provinces decreased. Ha Noi and Nghe An are the two provinces with the highest population sizes in northern Vietnam. Provinces with higher population densities tend to have higher incidence rates of cases sent to the National Children's Hospital. Densely populated provinces may have higher transmission rates of infectious diseases, leading to higher incidence rates. The healthcare systems in these provinces typically serve larger patient numbers and are more prone to overload, necessitating the transfer of cases to the National Children's Hospital. During outbreaks, policymakers should consider population density when designing and implementing public health policies to ensure that higher-risk regions are prioritized and adequately supported. Being the capital, Ha Noi is also characterized by a very high volume of human mobility [24]. A research using data of the 2017–2019 outbreak in southern Vietnam also suggested that human mobility is one of the most important factors contributing to inter-provincial transmission [25]. In March 2019, the outbreak seemed to have reached its peak and have spread to almost all provinces in the north, as the national pediatric hospital received patients from 22 out of 29 provinces of northern Vietnam. A hypothesis has been stated that measles outbreak could be triggered by large volume of inter-provincial travel and person-to-person transmission during the Lunar New Year [25, 26], which usually happens in January or February in Vietnam. Concerns about rapid expansion after holidays has also been raised in the previous measles outbreak in Vietnam in 2009 and 2014 [12]. In 2014, nationwide measles vaccination campaigns for children were triggered that led to the control of the outbreak [12]. Similar vaccination campaigns were organized in 2019 when the outbreak was at its peak. Given that increased human mobility during holidays can potentially contribute to a surge in measles cases, future control strategies, like vaccination campaigns, would be more effective if planned before holidays. These strategies should focus on assessing population-level susceptibility rather than waiting until an outbreak has already occurred.

Research in Vietnam has found that children from ethnic minority groups, lower-educated mothers, and the poorest households are less likely to receive the measles vaccine due to limited access to healthcare, lack of awareness, and financial constraints [11]. Conversely, in economically developed areas like Ha Noi, highly educated and wealthy mothers avoid vaccinating their children due to concerns about vaccine safety and side effects [11]. This variation in vaccination coverage is strongly linked to measles incidence [25], particularly affecting children with chronic diseases whose parents are often more cautious about vaccination. Additionally, socio-economic disparities impact the risk of hospital-acquired infections, as underprivileged populations have less access to quality healthcare and face delays in treatment, increasing their vulnerability.

Our research findings indicate that some provinces experienced infection starting from a suspected or confirmed case from the National Children's Hospital or within provincial hospitals before the emergence of community-acquired hospitalizations. The transmission of measles within healthcare facilities can amplify the propagation of outbreaks that originate from community-acquired cases and subsequent hospitalizations, potentially resulting in longer outbreak periods during 2017 to 2019 compared to previous occurrences. And vice versa: the outbreak lasting for such a long period of time may also exacerbate nosocomial infection since resource constraints, such as lack of space and inadequate ventilation, make isolating measles patients very challenging, thus contributing to the spread within healthcare settings [14]. Controlling nosocomial infections remains challenging. Healthcare facilities are usually full of in-patients with compromised immune systems and lower vaccination rates due to chronic and congenital illnesses. Measles patients sometimes present with initial respiratory symptoms or fever alone without the classic accompanying symptoms of cough, coryza, and rash. In our study, only 40.9% of patients were diagnosed with measles upon admission, making early diagnosis and tracking difficult before admission. Many prevention measures are known such as performing serological test for all patients with atypical clinical manifestation, strengthening infection control measures in healthcare facilities, and early isolation of suspected cases [27]. However, integrating these measures in the context of low and middle-income countries like Vietnam presents significant challenges. From our experience at the National Children's Hospital, we have managed to maintain a nosocomial infection rate of 5%, but complete eradication of these cases remains unattainable as long as measles persists within the community and necessitates hospitalization for treatment.

Children with underlying chronic diseases or comorbid conditions face a dilemma regarding vaccination. Concerns regarding potential side effects and the fragility of their health often lead parents to hesitate in vaccinating their children. However, the consequence of remaining unvaccinated is an elevated risk of contracting and progressing to severe diseases [28]. Our study found that children with chronic diseases have a higher risk of nosocomial infection. Children with chronic diseases are reported to exhibit reduced immune responses and more rapid waning antibody titers [29]. They usually visit the hospital more often, and spend more time in the hospital, which also explains the higher risk of contracting hospital-acquired infections. In Vietnam, vaccination centers frequently decline to administer vaccines to these children due to concerns related to post-vaccination

complications, parents complains and a lack of detailed guidelines for vaccination for these subjects. Until now, the National Children's Hospital is the only facility in northern Vietnam capable of vaccinating children with chronic diseases. Our findings highlight the need for enhanced protection and specialized guidelines for this vulnerable population to prevent future outbreaks. Future studies should investigate the attitudes of parents of children with chronic diseases towards measles vaccination, conducting long-term follow-up on patients with chronic diseases who contracted measles to understand the lasting impacts on their health and quality of life, and evaluate the vaccine effectiveness in this group to help inform better decisions about the benefits and risks for these vulnerable children.

Limitation

A major limitation of our study is that our data only comes from one hospital. In absence of community-wide data, we were unable to make an inference about the probability of infection, and it is very difficult to see the trend of overall measles outbreak during the study period. In addition, the reported severity proportion in our study is expected to be greater than that in smaller hospitals, primarily because the National Children's Hospital serves as the region's last-resort facility for pediatric care, receiving a higher number of moderate to severe cases. Risk factors for severe morbidity such as nutrition, lactation status, laboratory tests or vitamin A dose were not available to be analyzed in this study. Our study categorizes children as "unvaccinated" if they received no vaccine doses, or "vaccinated" if they received at least one dose, but our data lacks detailed information on the number of doses. This limitation may affect findings, as vaccine effectiveness can be lower among partially vaccinated children. Additionally, the source of data regarding the type of vaccination report was unavailable. While approximately 90% of vaccination status information was collected from vaccination records or electronic medical records, we were unable to investigate the association between the reliability of vaccination report sources and measles cases among vaccinated children.

Conclusion

In conclusion, our study highlights the early transmission of measles within healthcare settings before community-acquired cases emerged in many provinces in the 2017–2019 outbreak. Beyond existing non-pharmaceutical interventions in hospital settings, we propose strengthening these efforts during non-outbreak periods through regular staff training on infection control, improving early detection and isolation of suspected cases, and conducting periodic audits of infection control practices. Measles cases with chronic diseases appeared to have lower proportion of vaccination, with the most pronounced disparity observed among children aged 18 months and older. Comprehensive vaccination guidelines and increased parental awareness regarding the importance and safety of vaccination are vital for protecting high-risk individuals in the future.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12879-024-09816-w.

Supplementary Material 1

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Author contributions
Conceptualization: NTP, TMD, DHH, PHP, TCV and TO; funding acquisition: NTP, TMD, and MC; methodology: NTP, TMD, QTP, TO and MC; data analysis: NTP, TO, and MC; investigation: NTP, TMD, DHH, TMD, TCV and PHP; resources: TMD; data curation: NTP, TO, and MC; supervision: NTP, TMD, and MC; project administration: NTP; validation: NTP, TO, TMD, MC and PHP; visualization: NTP, and TO; writing—original draft preparation, NTP, and TO; writing— review and editing, NTP, TMD, TO, MC, QTP and DHH.

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Data availability
Data available on request from the corresponding author due to institutional privacy restrictions.

Declarations

Ethics approval and consent to participate
The study was approved by the Institutional Review Board of the Vietnam National Children's Hospital, which waived the requirement for consent to participate because the analysis was retrospective (Approval reference number: 473/BVNTW-HDDD, IRB identifier: IRB-VN01037/IRB00011976/FWA00028418).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Director of the Vietnam National Children's Hospital, Hanoi, Vietnam
[2]Pediatric Department, School of Medicine and Pharmacy, Vietnam National University, Hanoi, Vietnam
[3]Mathematical Modelling Group, Oxford University Clinical Research Unit, Ho Chi Minh City 70000, Vietnam
[4]Surgical Cadiac Intensive Care Unit, Vietnam National Children's Hospital, Hanoi, Vietnam
[5]Vice head of Department (Communicable Disease Control), National Institute of Hygiene and Epidemiology, Hanoi, Vietnam
[6]Health Emergencies Programme, WHO Viet Nam, Hanoi, Vietnam
[7]Pediatric Intensive Care Unit, Vietnam National Children's Hospital, Hanoi, Vietnam
[8]Wellcome Trust Major Overseas Programme, Oxford University Clinical Research Unit, Ho Chi Minh City 70000, Vietnam
[9]Centre for Tropical Medicine and Global Health, Nuffield Department of Medicine, University of Oxford, Oxford OX3 7BN, UK

[10]Research Institute for Child Health, Field Epidemiology Training Program - Ministry of Health, Vietnam National Children's Hospital, Hanoi, Vietnam
[11]Field Epidemiology Training Program - Ministry of Health, Hanoi, Vietnam

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