Applied Epidemiology in the Vietnamese context

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Declaration

I declare that the content within this thesis is my original work. This thesis does not include any content that has been used to obtain another academic degree or diploma from any institution. To the best of my knowledge, it does not contain any previously published material authored by someone else, except when appropriately cited in the text. Any contributions made by others to the research are duly recognized in the respective chapter prefaces.

Huyen Thi Nguyen

October 2023

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I am grateful to the participants of my projects, whose cooperation and involvement have been crucial in gathering the necessary data and insights. Their willingness to contribute to advancing medical knowledge is commendable.

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I would like to express my gratitude to the Pasteur Institute in Ho Chi Minh City, where I worked before joining the MAE course and where I will return to work after graduation. This Institute provided the foundation, experience, and motivation for me to participate in this exciting course. I deeply appreciate the institute's leadership and colleagues who supported, listened, and shared their workload at the Institute with me during my study.

I am also grateful to the ANU HDR Fee Remission Merit Scholarship and the ASEAN-Australian Health Security Fellowship (274/2019), the Australian Government Department of Home Affairs, for their financial support, which made these projects possible and provided me this precious opportunity to build the certain foundation of my academic career.

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This two-year was a tremendous experience for my self-growth and my public health capacity. This research would not have been possible without the collective efforts and contributions of all those mentioned above. I am truly honored and privileged to have had their support, and I am confident that their influence will continue to shape my future endeavors in the field of Applied Epidemiology and Public health.

October 25th 2023.

Huyen Thi Nguyen.

Abstract

This thesis outlines the projects I conducted to address the requirements of the Master of Applied Epidemiology Program (MAE). My field placement was undertaken at the Department of Communicable Disease Control and Prevention of the National Institute of Hygiene and Epidemiology (NIHE) in Hanoi, Vietnam.

Chapter 1 – Introduction:

This chapter provides an overview of my field placement, describes how I met the MAE requirements and discusses other side projects I was involved in during my MAE in addition to the MAE competencies.

Chapter 2 – Investigation of an outbreak: *An outbreak of avian influenza A/H5N1 in human in Phu Tho province, Vietnam, 2022.*

I investigated an Avian Influenza H5N1 outbreak of a single case in a 4-year old female patient in Phu Tho, Vietnam. The investigation did not identify any additional human cases among 67 community contacts or among animals from five environmental and animal samples. However, my findings suggest a risk of disease transmission due to backyard poultry raising, free-ranging poultry, and lack of vaccination. I presented this project as an oral poster at the Communicable Disease and Immunisation Conference 2023 (CDIC2023) in Perth, Western Australia (Conference presentation 1), and delivered a long oral presentation at the 13th International Conference on Public Health among the Greater Mekong Subregion countries (GMS13) in Vietnam (Conference presentation 2).

Chapter 3 – Analyze a public health dataset: *An examination of measles transmission at National Children's hospital in Hanoi, Vietnam, 2017-2019.*

I analysed data for 2.056 measles patients diagnosed as laboratory confirmed-cases at the National Children's Hospital in Hanoi from 2017 to 2019. The results provided evidence of measles transmission in the hospital setting, particularly among unvaccinated pediatric patients. Coinfections with other agents including adenovirus, respiratory syncytial virus, and pertussis were statistically significant among patients in the hospital acquisition group. I presentated this research at CDIC2023 (Conference presentation 3) and GMS13 (Conference presentation 4).

I also conducted a **Literature Review** on measles outbreak in hospital environments to understand the outbreak characteristics in the healthcare settings and examine control measures employed.

Chapter 4 – Evaluate a surveillance system: *Evaluating the Japanese Encephalitis (JE) Disease surveillance system in Son La province, Vietnam, 2016-2022.*

I completed an evaluation of the Japanese Encephalitis (JE) surveillance system in Son La province, Vietnam (2016 to 2022), assessing its four main attributes: simplicity, data quality, flexibility, and sensitivity. I used the Vietnam National Electronic Disease Surveillance System (NEDSS) including the JE surveillance as the basis for evaluation. I found that data quality required improvement, especially in updating disease diagnoses post-laboratory testing, and NEDSS sensitivity stayed below 75%, necessitating solutions for better community-based surveillance and data quality at lower levels. Solutions to enhance community-based active surveillance and data quality at lower levels were recommended.

Chapter 5 – Design and conduct an epidemiological study: *Analyzing trends and predicting future outbreaks of Measles in Vietnam using time series analysis.*

For my epidemiological research project I completed a time series analysis to analyze historical trends and predict future measles outbreaks in Vietnam. I utilised available reported data collected from yearbooks and official reports nationwide over a 20-year period from 2003 to 2022. The analysis revealed that measles cases in Vietnam fluctuated over the period, with seasonal variation and occasional nationwide outbreaks. The data indicated a potential 4 to 5-year periodicity for measles epidemics in the country between 2003 and 2022, with the most recent epidemic occurring in 2018-2019.

Chapter 6 – Other MAE requirements:

In this chapter, I report on additional MAE requirements I completed during my fellowship, including publishing **a Lay Audience Report** targeted at readers of the Health & Lifestyle journal, an official press outlet of the Vietnam Ministry of Health; presenting my **Lesson From The Field** on using QGIS to my MAE cohort, and my **Teaching Experience** of QGIS to Vietnamese students.

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Chapter 1. Introduction

List of Abbreviations – Chapter 1

ANU	Australian National University
MAE	Master of Applied Epidemiology Program
NIHE	National Institute of Hygiene and Epidemiology
COVID-19	Coronavirus Disease 2019
SARS	Severe acute respiratory syndrome
RRT	Rapid response team
JE	Japanese Encephalitis
WHO	World Health Organization
EPI	Expanded Programme on Immunization
UNICEF	United Nations Children's Fund

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1.1 Introduction to field placement

I commenced as an MAE student at the National Institute of Hygiene and Epidemiology (NIHE) in Hanoi, Vietnam on the 14th February, 2022. However, I remained in Ho Chi Minh city, where I usually live, to attend course block 1 online. This block was delivered online for our cohort due to travel restrictions related to the COVID-19 pandemic. I was introduced as an MAE Scholar and the field placement in Vietnam to the Department of Communicable Disease Control and Prevention, NIHE and my field supervisor (Dr. Pham Quang Thai) who is the vice head of the department. I was immediately incorporated into the NIHE research team working on the cost of illness of Japanese encephalitis and sequelae care in Vietnam. This study included field investigations in southern Vietnam, where I live and work. As I was familiar with the area, the research team and my academic supervisor agreed that I could remain in Ho Chi Minh City to serve as the main focal point for coordinating the study in the south. I relocated from Ho Chi Minh city to Hanoi to undertake by field placement at NIHE as an MAE student on 17th May, 2022.

The NIHE is a leading public health institution in Vietnam. Established in 1926, the institute is responsible for a wide range of activities related to public health, including disease surveillance, outbreak investigation, laboratory testing, research, and training.

The NIHE plays a critical role in the prevention and control of infectious diseases in Vietnam, and has been involved in the investigation of high-profile outbreaks, including the SARS outbreak in 2003, the H5N1 Avian Influenza outbreak in 2004 and the COVID-19 pandemic recently. The institute also provides diagnostic testing for infectious diseases and conducts research on various aspects of infectious diseases.

The Department of Communicable Disease Control and Prevention is a key department within the NIHE responsible for the prevention, control, and management of communicable diseases in Vietnam. The department is currently headed by Dr. Ngu Duy Nghia, Assoc.Prof. Pham Quang Thai is the vice head and is tasked with conducting epidemiological studies, disease surveillance, immunisation surveillance, and prevention and control activities in the 28-province Northern region and other localities nationwide. The department also coordinates with other departments within the institute or with other institute or organisations to investigate, monitor, and detect microbial agents and disease sources, conduct field epidemiology training, and perform scientific activities and consultations. Furthermore, the department works closely with other government agencies and international organizations to develop policies and strategies to prevent and control communicable diseases in Vietnam. The department has played a critical role in the response to the COVID-19 pandemic in Vietnam, including the development of testing protocols and the establishment of quarantine facilities.

1.2 Summary of field placement activities

My main tasks in the department have involved participating as a member of the NIHE'S Rapid Response Team (RRT) for disease outbreaks in the North Vietnam. This has involved conducting literature reviews, field investigations, attending meetings, and writing reports for public health emergencies. During this period at the Department of Communicable Disease Control and Prevention, NIHE, I have also worked with the RRT in investigating Avian Influenza outbreaks in Phu Tho province, participated in meetings and literature review related to mysterious liver disease, and worked on the emergence of a rare fungal infection (Mucormycosis) after the COVID-19 pandemic at a major hospital in Hanoi. Additionally, I was involved in the Rotavirus outbreak at the National Children's Hospital in Hanoi and conducted literature reviews as well as participating in a monkeypox workshop.

Throughout the execution of these projects to meet the MAE program's requirements, I served as the principal investigator or co-principal investigator of my projects, collaborating with colleagues at NIHE and relevant partners to carry out activities for each project as outlined in the chapters of this thesis.

In addition, I was also assigned as a support staff member for the vaccination program in the Northern region, participating in training courses, providing support, conducting assessments of vaccination rates, and storage of COVID-19 vaccines and expanded immunization vaccines in Lao Cai province.

During this time, we were working collaboratively with colleagues from other departments within NIHE, the General Department of Preventive Medicine, the Ministry of Health, Hanoi Medical University, the World Health Organization Vietnam, other regional institutes and various provinces.

NIHE is an amazing place for applied epidemiology scholars and interns to enhance their academic careers. In the Department of Communicable Disease Control and Prevention, and NIHE as a whole, I have had the opportunity to gain hands-on experience in various public health activities related to communicable disease control and prevention, under the guidance of experienced researchers and public health professionals. These opportunities have been invaluable in contributing to forming my future career and my life

1.3 Summary of MAE requirements

Requirement	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6
Investigate an acute public health problem or threat	✓				
Analyze a public health data set		✓			
Evaluate a surveillance system			✓		
Design and conduct an epidemiological study				✓	
Literature review		✓			
Report to a non-scientific audience					✓
Lesson from the field					✓
Teaching					✓
Advanced manuscript submission to or publication in an international peer-reviewed journal	✓				
Conference presentation	✓	✓			

1.3.1 Core requirements

1. Investigate an acute public health problem or threat (Chapter 2)

An outbreak of Avian Influenza A/H5N1 in human in Phu Tho province, Vietnam, 2022.

2. Analyze a public health dataset (Chapter 3)

An examination of measles transmission at National Children's hospital in Hanoi, Vietnam, 2017-2019.

3. Evaluate a surveillance system (Chapter 4)

Evaluating the Japanese Encephalitis (JE) Disease surveillance system in Son La province, Vietnam, 2016-2022.

4. Design and conduct an epidemiological study (Chapter 5)

Analyzing trends and predicting future outbreaks of Measles in Vietnam using time series analysis.

1.3.2 Other requirements

1. Literature review (Chapter 3)

Measles outbreak in hospital environment

2. Report to a non-scientific audience (Chapter 6)

Huyen Nguyen, Pham Quang Thai (2022) "***The Risk of Resurgence in Vaccine Preventable Infections after the easing of COVID-19 control***" (Original title in Vietnamese: "*Nguy cơ tái bùng phát bệnh có thể dự phòng bằng vaccine*"), Suc Khoe & Doi Song Newspaper - Official press representatives of Vietnam Ministry of Health, 28 June 2022. Available at: https://suckhoedoisong.vn/nguy-co-tai-bung-phat-benh-co-the-du-phong-bang-vaccine-169220628080144373.htm

3. Publication or advanced draft submission to an international peer-reviewed journal (Chapter 3)

Draft submission:

Huyen Thi Nguyen#^, Khanh Cong Nguyen#, Tu Huy Ngo, Bich-Hanh Thi Cu, Viet Phong Nguyen, Hien Thi Nguyen, Trang Thu Vu, Nghia Duy Ngu, Duong Nhu Tran, Hung Manh Vu, Diep Thi Nguyen, Oanh Trong Nguyen, Viet Hai Ha, Duc Anh Dang, Florian Vogt, Samantha Colquhoun*, Thai Quang Pham*; "**Lessons learned from an Avian Influenza Outbreak in Vietnam, 2022".**

(shared) first authorship

* (shared) last authorship

^ corresponding authorship

4. Conference presentation (Chapter 2, 3)

- **Huyen Thi Nguyen**, Khanh Cong Nguyen, Tu Huy Ngo, Bich-Hanh Thi Cu, Viet Phong Nguyen, Hien Thi Nguyen, Trang Thu Vu, Nghia Duy Ngu, Duong Nhu Tran, Hung Manh Vu, Diep Thi Nguyen, Oanh Trong Nguyen, Viet Hai Ha, Duc Anh Dang, Florian Vogt, Samantha Colquhoun, Thai Quang Pham; "**Lessons learned from an Avian Influenza Outbreak in Vietnam, 2022**". Poster oral presentation (6 minutes), Communicable Diseases and Immunisation Conference 2023 **(CDIC2023),** 19 – 21 June 2023 in Perth, Western Australia.

- **Huyen Thi Nguyen**, Khanh Cong Nguyen, Tu Huy Ngo, Bich-Hanh Thi Cu, Viet Phong Nguyen, Hien Thi Nguyen, Trang Thu Vu, Nghia Duy Ngu, Duong Nhu Tran, Hung Manh Vu, Diep Thi Nguyen, Oanh Trong Nguyen, Viet Hai Ha, Duc Anh Dang, Florian Vogt, Samantha Colquhoun, Thai Quang Pham; "**Lessons learned from an Avian Influenza Outbreak in Vietnam, 2022".** Long oral presentation (8 minutes), The 13th International Conference on Public Health among the Greater Mekong Subregion countries 2023 **(GMS-13),** 01 – 02 July 2023 in Hue, Vietnam.

- **Huyen Thi Nguyen,** Nhung TH Pham, Dang Hai Le, Khanh Cong Nguyen, Khang Van Pham, Huong Thi Thu Nguyen, Trang Thu Vu, Hien Thi Nguyen, Dien Minh Tran, Florian Vogt, Samantha Colquhoun, Thai Quang Pham. "An examination of measles transmission at a pediatric hospital in Vietnam, 2017-2019". Oral long presentation (10 minutes), Communicable Diseases and Immunisation Conference 2023 **(CDIC2023)**, 19 – 21 June 2023 in Perth, Western Australia.

- **Huyen Thi Nguyen,** Nhung TH Pham, Dang Hai Le, Khanh Cong Nguyen, Khang Van Pham, Huong Thi Thu Nguyen, Trang Thu Vu, Hien Thi Nguyen, Dien Minh Tran, Florian Vogt, Samantha Colquhoun, Thai Quang Pham. "An examination of measles transmission at a pediatric hospital in Vietnam, 2017-2019". Poster presentation, The 13th International Conference on Public Health among the Greater Mekong Subregion countries 2023 **(GMS-13)**, 01 – 02 July 2023 in Hue, Vietnam.

5. Teaching (Chapter 6)

- Lessons from the field: ***Mapping an outbreak: Plotting cases with specified spatial coordinates to QGIS.***
- Teaching experience: ***Guide to Using QGIS Software for Drawing Infectious Disease Epidemiology Maps.***

6. Coursework

- POPH8916 (Outbreak Investigation): Semester 1, 2022.
- POPH8917 (Public Health Surveillance): Semester 1, 2022.
- POPH8913 (Analysis of Public Health Data): Semester 2, 2023.
- POPH8914 (Issues in Applied Epidemiology): Semester 1, 2023.
- POPH8915 (Research Design and Methods): Semester 1, 2023.

1.4 Other activities

(Side projects – Chapter 1)

During my time in MAE and while working at NIHE, I also got involved in some side projects.

Project 1: Estimating the cost of illness of acute Japanese encephalitis and sequelae care in Vietnam: A cross sectional study.

This was a multinational research project led by the National Institute of Hygiene and Epidemiology (NIHE) in Vietnam. Shortly after I joined the Master of Applied Epidemiology (MAE) program at the end of February 2022, my field supervisor, Dr. Thai, who was also the co-principal investigator of this project, assigned me the role of being the main coordinator of the research in the Southern region. This region was one of the two main research sites for the study, comprising nearly 50% of the study population with 240 subjects in total in Vietnam. The study aimed to estimate the cost of acute care for Japanese encephalitis (JE), the cost of initial rehabilitation and sequelae care by severity within the first year after hospital discharge, and the cost of long-term rehabilitation and sequelae care by severity between two and ten years after hospital discharge. My task involved leading a group of research staff in the Southern region, providing support for training on the research protocol and the use of the data collection tools via the RedCap application, handling administrative procedures between NIHE, the Pasteur Institute in Ho Chi Minh City, and 15 provinces in the Southern region, participating in field investigations at households, reporting the survey results, and verifying survey information, as well as budget finalization.

The interview survey activities were completed in April 2022, with a total of 110 collected samples from our group, including 16 acute JE care cases, 38 initial rehabilitation and sequelae care cases, and 56 long-term rehabilitation and sequelae care cases (Figure 1.1).

The research team's activities for the Southern region are presented in Figure 1.1 and Figure 1.2.

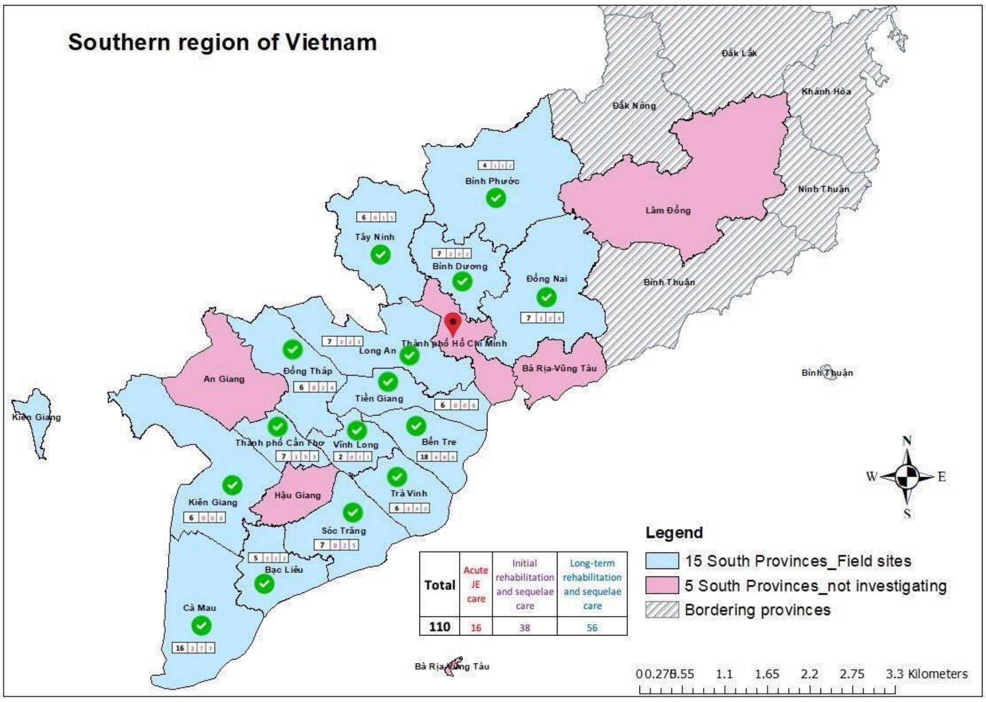


Figure 1.1. Locations and corresponding investigated JE cases by the Southern research team, Southern Vietnam, 2022.

In Binh Duong province

In Long An province

In Can Tho province

In Tra Vinh province

In Ca Mau province

In Ben Tre province

In Soc Trang province

In Vinh Long province

Research summary meeting in Da Nang province, June 2022.

Figure 1.2. Photos of the Southern research team in the field, Southern Vietnam, 2022

Project 2: Participation in the Rapid Response Team (RRT) of NIHE for Monkeypox outbreak response.

In May 2022, as monkeypox re-emerged in some countries around the world and the risk of monkeypox entering Vietnam became substantial, I was assigned as a member of NIHE's Rapid Response Team (RRT) to be ready for outbreak response activities in North Vietnam when cases appeared. My role included conducting weekly literature reviews for the RRT.

On July 23, 2022, the Director-General of WHO declared monkeypox as a public health emergency. Subsequently, the Vietnamese Ministry of Health held an online meeting on July 26, 2022, to discuss response measures in the event of an outbreak. Given this context, I also prepared and shared updates on epidemiological situations, clinical characteristics, and prevention measures for my colleagues at NIHE during a seminar on July 26, 2022, held at the Department of Communicable Disease Control and Prevention, NIHE. Information from the seminar was posted on NIHE's website (in Vietnamese: https://nihe.org.vn/vi/seminar-capnhat-dich-te-hoc-benh-dau-mua-khi-tren-the-gioi), and the image below (Figure 1.3) shows me giving the presentation.

Figure 1.3. MD. Huyen Nguyen presenting during the Monkeypox seminar at NIHE

I continued to provide disease updates in my presentations in the following weeks. The most comprehensive report was attached in the Appendix 1.1.

During this time, I participated in online World Health Organization (WHO) training related to monkeypox, including:

- A WHO seminar dated July 27, 2022: https://www.who.int/news-room/events/detail/2022/07/27/default-calendar/WHO-EPI-WIN-webinar-how-is-monkeypox-spreading
- Self-paced learning through WHO's OpenWHO website on August 3-4, 2022: "*Monkeypox: Epidemiology, preparedness and response for African outbreak contexts*".

World Health Organization

HEALTH EMERGENCIES programme

Record of Achievement

Monkeypox: Epidemiology, preparedness and response for African outbreak contexts

Huyen Thi Nguyen

August 4, 2022

Verify online: https://openwho.org/verify/xezob-nacyn-paliz-fefyp-nusag

Project 3: To monitor implementation of COVID-19 vaccines and other vaccines in the expanded program on immunization (EPI) in Lao Cai province

The Expanded Program on Immunization (EPI) in Vietnam, established in 1981 with support from WHO and UNICEF, is a crucial public health initiative aimed at achieving universal immunization for all children under one year of age. This program has played a pivotal role in reducing vaccine-preventable diseases, operating through a network of offices and centres, providing monthly immunization services at fixed and mobile sites, including hard-to-reach areas. Over the years, new vaccines and vaccination campaigns have been incorporated into the program, leading to significant achievements in disease prevention. However, challenges related to vaccine access, cold chain management, and infrastructure continue to persist. The emergence of COVID-19 has posed unprecedented challenges, requiring mass vaccination efforts. Therefore, this evaluation project placed a strong emphasis on the preservation and utilization of COVID-19 vaccines, integrated with regular monitoring activities within the immunization surveillance system.

In the course of this project, I conducted a thorough literature review regarding the vaccine cold chain and participated in a field trip to Lao Cai province from November 1 to 4, 2022, alongside colleagues from the Northern EPI Office at NIHE (Figure 1.4).

The project was primarily focused on monitoring the implementation of COVID-19 vaccines and other vaccines within the Expanded Program on Immunization (EPI) at the provincial level. Our efforts revolved around identifying gaps in vaccine implementation, encompassing immunization practices and cold chain management at the local level. We offered recommendations for addressing these issues, aiming to maintain high vaccine coverage rates, enhance vaccine storage quality, and minimize wastage, thereby ensuring efficient vaccine utilization.

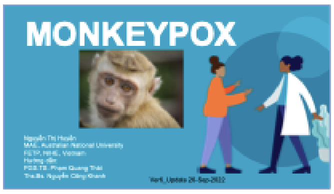
Figure 1.4. Photos of the team checking vaccine refrigerators and providing guidance on electronic temperature monitoring devices and water packs of vaccine carriers in Lao Cai province.

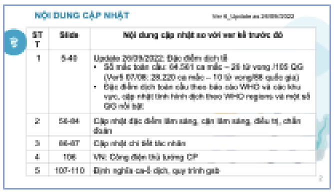
Project 4: Assessing the current situation and factors impacting microbiological laboratory capacity for zoonoses in Vietnam in 2023.

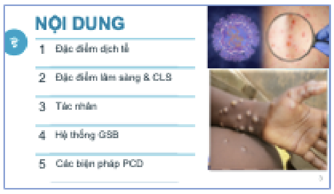
Vietnam is recognized as a country at high risk for the emergence and re-emergence of zoonotic diseases. These diseases are common due to the practice of consuming undercooked animal products and frequent interactions between animals and humans. The government of Vietnam has identified five priority zoonoses: highly pathogenic Avian Influenza, rabies, leptospirosis, anthrax, and Streptococcus suis. The COVID-19 pandemic has had a significant impact on the country's health system, leading to substantial investments and upgrades in the laboratory system, particularly in microbiology labs, to respond to disease risks.

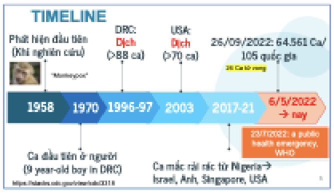
To comprehensively quantify and identify the changes in laboratory capacity for zoonotic diseases across the country, a nationwide study was conducted in 2023. Initially, I had planned to develop this project as part of my epidemiology study, but due to various feasibility reasons, I ultimately chose not to pursue that path. I drafted the initial research proposal, and the project was subsequently carried out in collaboration with a research team at NIHE and Hanoi Medical University.

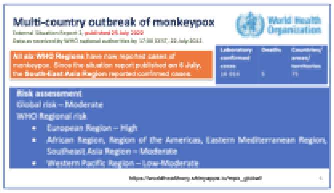
1.5 Appendix 1.1: Presentation for the review of Monkeypox at NIHE

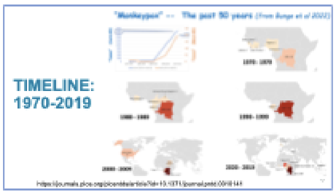


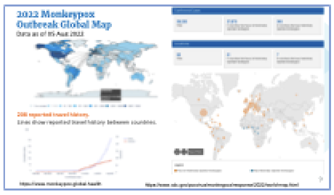


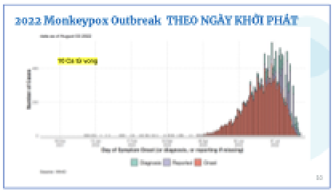


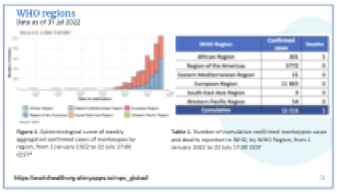


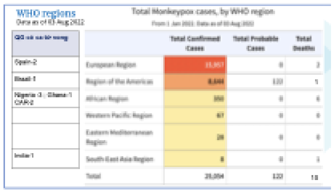


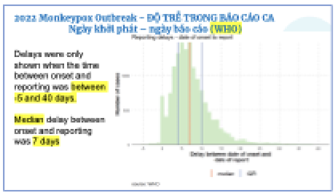


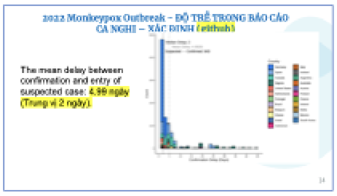


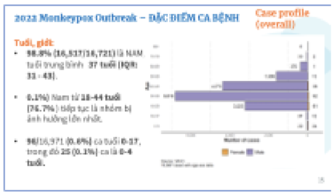


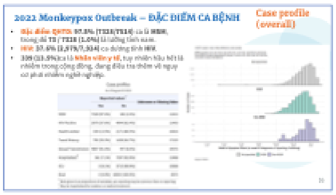


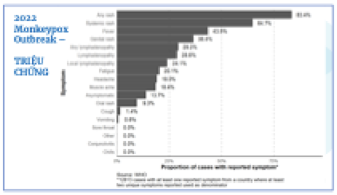


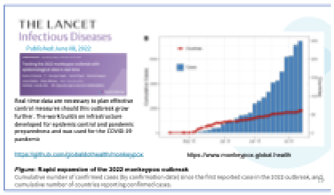


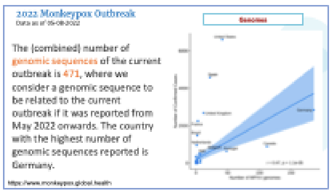


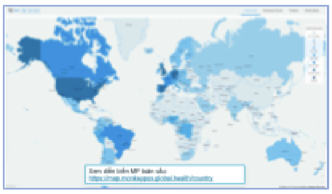


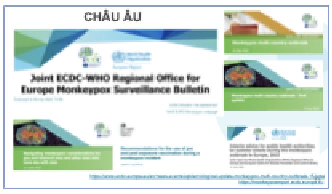


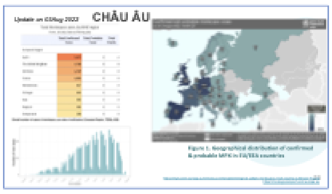


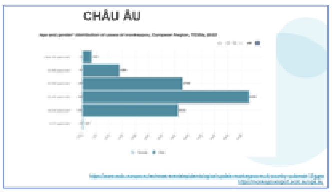


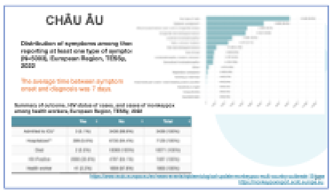


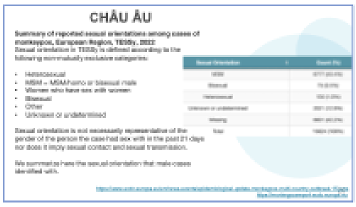
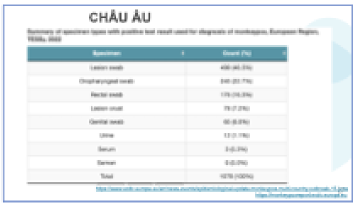
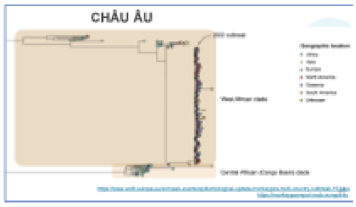
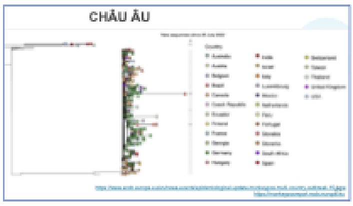
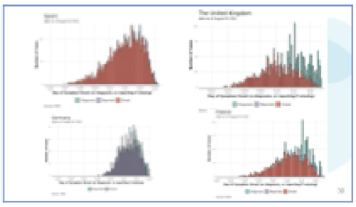
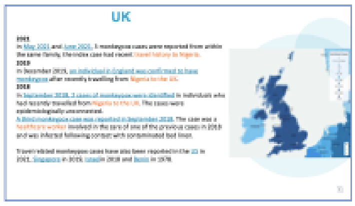
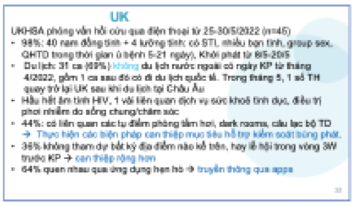
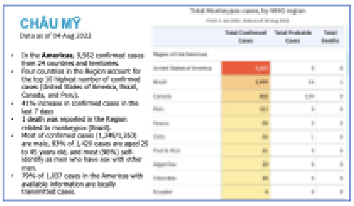
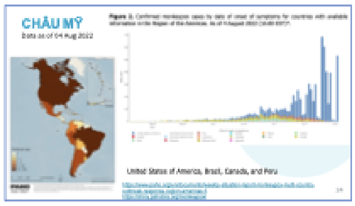






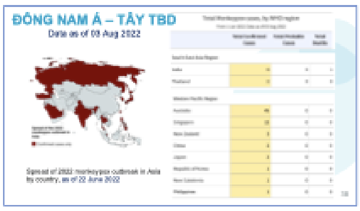




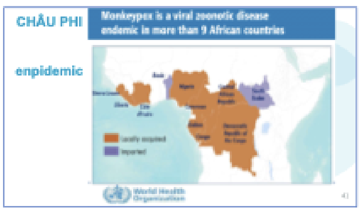
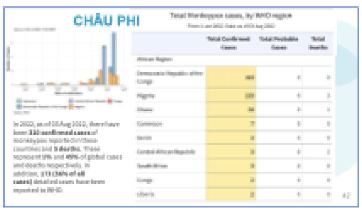
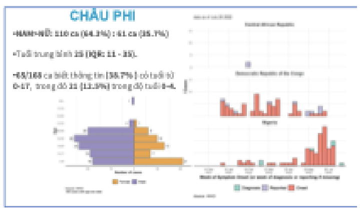
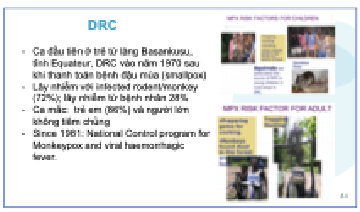
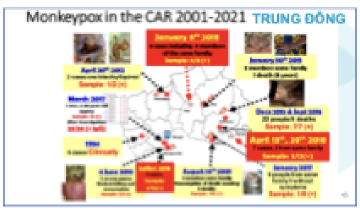
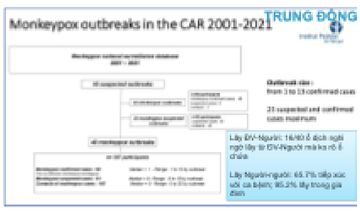
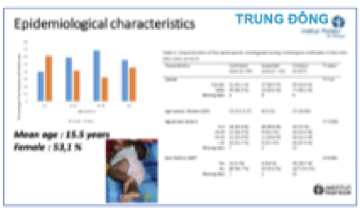
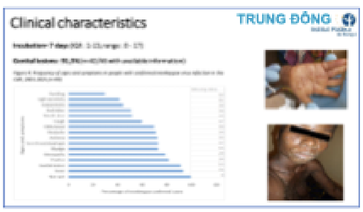

CHÂU ÂU

CHÂU ÂU

CHÂU ÂU

CHÂU ÂU


UK

UK

CHÂU MỸ
Data as of 04 Aug 2022

CHÂU MỸ
Data as of 04 Aug 2022

USA

USA
OUTBREAK 2022

USA
OUTBREAK 2022

ĐÔNG NAM Á – TÂY TBD
Data as of 03 Aug 2022

CÁC QUỐC GIA LÂN CẬN VIỆT NAM

ĐỊA TRUNG HẢI
Data as of 03 Aug 2022

CHÂU PHI
Monkeypox is a viral zoonotic disease endemic in more than 9 African countries
enpidemic

CHÂU PHI

CHÂU PHI

DRC

Monkeypox in the CAR 2001-2021
TRUNG ĐÔNG

Monkeypox outbreaks in the CAR 2001-2021
TRUNG ĐÔNG

Epidemiological characteristics
TRUNG ĐÔNG

Clinical characteristics
TRUNG ĐÔNG

Disease outcomes and Case Fatality Ratio
TRUNG ĐÔNG


History of human monkeypox in Nigeria
First case of human monkeypox in Nigeria was reported in April 1971
Third human case reported in Nov 1978
Animal surveillance


NIGERIA
SITUATION REPORT
Male: 68%
Female: 32%

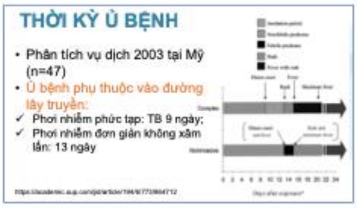

ĐẶC ĐIỂM LÂY NHIỄM
Endemic: Tây và Trung Phi → Hầu hết các ca mắc mới ở Tây Phi có tiền sử du lịch tới Châu Âu và Bắc Mỹ.
Hầu hết các trường hợp liên quan sức khỏe tình dục hoặc các dịch vụ y tế/CSYT ban đầu, và chủ yếu liên quan đến nam giới quan hệ tình dục đồng giới (MSM).
"Monkeypox is spreading and gay and bisexual men have been affected disproportionately."
"Monkeypox does not respect anyone's sexuality

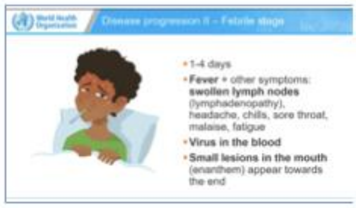

ĐẶC ĐIỂM LÂY NHIỄM
Cho đến nay, tất cả các trường hợp được xác định ở các quốc gia không lưu hành bệnh có mẫu được xác nhận bằng PCR đều được xác định là bị nhiễm chủng Tây Phi.
Có hai nhóm bệnh đậu khỉ được biết đến:
1) Nhóm đặc hữu ở Tây Phi (WA)
- Liên quan đến tỷ lệ tử vong chung thấp hơn <3%
2) Nhóm ở khu vực lưu vực Congo (CB)
- Dường như thường xuyên gây ra bệnh nặng hơn với tỷ lệ tử vong theo trường hợp (CFR) được báo cáo trước đây từ 1-10%
(Cả hai ước tính đều dựa trên sự lấy nhiễm của một nhóm dân số trẻ nói chung ở châu Phi) .


2. ĐẶC ĐIỂM LÂM SÀNG


TIẾN TRIỂN BỆNH: 2-4 tuần (a self-limited disease)
GĐ xâm lấn
Sốt, nhức đầu dữ dội, nổi hạch, đau lưng-cơ, suy nhược
GĐ phát ban da
Mặt: 95%
Lòng bàn tay-chân: 75%
Màng nhầy miệng: 70%
6-13 ngày (5-21)
0-5 ngày
1-3 ngày
Outcome
Ủ bệnh


Disease progression I – Incubation
Duration: 5-21 days
No symptoms
Virus present in bloodstream (viremia) at the end of the incubation period


THỜI KỲ Ủ BỆNH
Phân tích vụ dịch 2003 tại Mỹ (n=47)
Ủ bệnh phụ thuộc vào đường lây truyền:
Phơi nhiễm phức tạp: TB 9 ngày;
Phơi nhiễm đơn giản không xâm lấn: 13 ngày


Disease progression II – Febrile stage
1-4 days
Fever + other symptoms: swollen lymph nodes (lymphadenopathy), headache, chills, sore throat, malaise, fatigue
Virus in the blood
Small lesions in the mouth (enanthem) appear towards the end

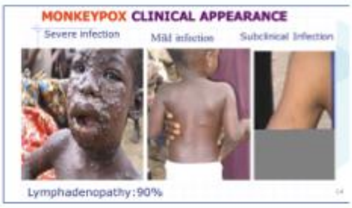

Disease progression III – Rash stage
Virus may be in the blood early in this stage
Virus is present in skin lesions
Antibodies are produced and become detectable


ĐẶC ĐIỂM BAN


ĐẶC ĐIỂM BAN
Phát ban tiến triển tuần tự từ dát (tổn thương có nền phẳng) đến sẩn (tổn thương cứng hơi nhô cao), mụn nước (tổn thương chứa đầy dịch trong), mụn mủ (tổn thương chứa đầy dịch vàng), và đóng vảy khô và bong ra.
Số lượng: vài đến vài nghìn.
Các tổn thương có thể liên kết với nhau cho đến khi các mảng da lớn bong ra.

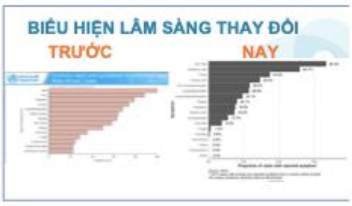

Disease progression III – Rash stage
Macule
Papule
Vesicle
Pustule
Crust


MỨC ĐỘ TỔN THƯƠNG DA


MONKEYPOX CLINICAL APPEARANCE
Severe infection
Mild infection
Subclinical infection
Lymphadenopathy:90%


Disease progression IV – Recovery
The patient has recovered
Specific antibodies are present in the blood
Scars may remain


Monkeypox symptoms – an overview
5-21 days
1-4 days
2-4 weeks
Days to weeks
Incubation period
Febrile stage
Rash stage
Recovery
No symptoms
Rash on the skin
No symptoms


BIỂU HIỆN LÂM SÀNG THAY ĐỔI
TRƯỚC
NAY


BIỂU HIỆN LÂM SÀNG THAY ĐỔI

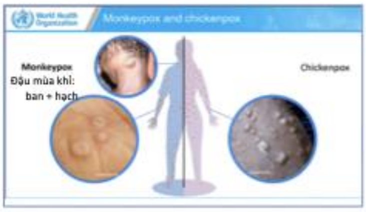

BIẾN CHỨNG
Nhiễm trùng thứ phát,
Viêm phế quản phổi,
Nhiễm trùng huyết,
Viêm não,
Nhiễm trùng giác mạc kèm theo mất thị lực.
Tử vong: Trước: 0-11% nói chung và cao hơn ở trẻ nhỏ
→ Tuy nhiên gần đây: 3-6%.

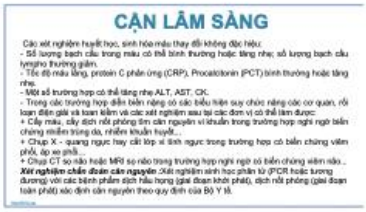

Long-term consequences of monkeypox
Scarring
Reduced skin pigmentation
Blindness

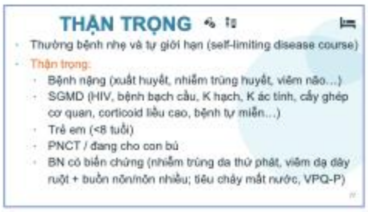

Monkeypox and other common rash illnesses
Monkeypox
Chickenpox
Measles
Symptoms
Fever
Rash appearance
Rash development
Rash distribution
Lymphadenopathy
Death


CHẨN ĐOÁN PHÂN BIỆT


Monkeypox, chickenpox and measles
Monkeypox
Chickenpox
Measles


Monkeypox and chickenpox
Monkeypox
Đậu mùa khỉ:
ban + hạch
Chickenpox

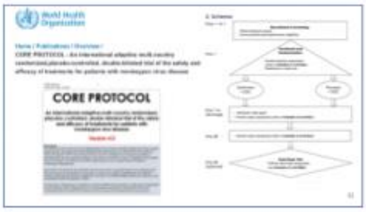

CẬN LÂM SÀNG


THẬN TRỌNG
Thường bệnh nhẹ và tự giới hạn (self-limiting disease course)
Thận trọng:
Bệnh nặng (xuất huyết, nhiễm trùng huyết, viêm não…)
SGMD (HIV, bệnh bạch cầu, K hạch, K ác tính, cấy ghép cơ quan, corticoid liều cao, bệnh tự miễn…)
Trẻ em (<8 tuổi)
PNCT / đang cho con bú
BN có biến chứng (nhiễm trùng da thứ phát, viêm dạ dày ruột + buồn nôn/nôn nhiều; tiêu chảy mất nước, VPQ-P)


ĐIỀU TRỊ
1. Nguyên tắc điều trị
- Thực hiện giám sát và cách ly ca bệnh nghi ngờ/ xác định;
- Điều trị triệu chứng là chủ yếu;
- Đảm bảo dinh dưỡng, cân bằng nước điện giải và hỗ trợ tâm lý;
- Sử dụng thuốc điều trị đặc hiệu ở những trường hợp nặng và cơ địa đặc biệt (trẻ sơ sinh, người cao tuổi, người bị suy giảm miễn dịch,…) theo khuyến cáo của Tổ chức Y tế thế giới.
- Theo dõi, phát hiện và xử trí kịp thời các tình trạng nặng, biến chứng của bệnh.


ĐIỀU TRỊ


ĐIỀU TRỊ
Thuốc điều trị đặc hiệu:
- Chỉ định:
Tecovirimat
Cidofovir
Brincidofovir


CORE PROTOCOL

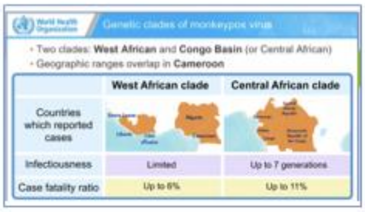

LẤY MẪU XÉT NGHIỆM
Bệnh phẩm:
Dịch tiết từ nốt ban (vỡ, bong tróc)
Da bong tróc từ nốt ban (da ướt/khô)
Huyết thanh
Ngoáy hầu họng
Nước tiểu
Nhân viên được tập huấn ATSH + Phòng hộ cá nhân PPE
Khử trùng dụng cụ và tẩy trùng KV lấy mẫu


Monkeypox: Which specimens to collect and when?
5-21 days
1-4 days
2-4 weeks
Days to weeks
Incubation period
Febrile stage
Rash stage
Recovery
No sample collected
Nasopharyngeal or oropharyngeal swab
Lesion fluid, Lesion roof or Lesion crust
Serum


Diagnostic tests – overview
5-21 days
1-4 days
2-4 weeks
Days to weeks
Incubation period
Febrile stage
Rash stage
Recovery

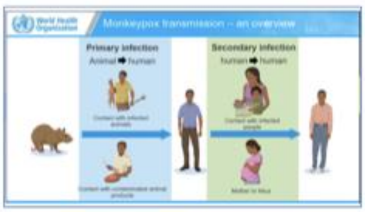

3. TÁC NHÂN
Tác nhân: Monkeypox Virus
Họ: Poxviridae
Giống: Orthopoxvirus
(Members: Variola virus-Smallpox, Vaccinia virus – Smallpox vaccine, cowpox virus)
DNA sợi đôi có vỏ bọc
2 main strains (CB, WA clade)

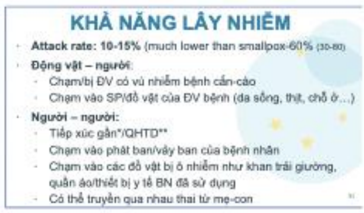

PHÂN LOẠI HỌ POXVIRIDAE
- Họ Poxviridae được phân loại thành 2 họ:
+ Entomopoxvirinae
+ Chorodopoxvirinae.
- Họ Chorodopoxvirinae được phân loại thành 18 chi
- Vi rút đậu mùa khỉ thuộc chi Orthopoxvirus

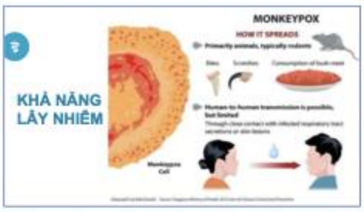

Genetic clades of monkeypox virus
Two clades: West African and Congo Basin (or Central African)
Geographic ranges overlap in Cameroon
West African clade
Central African clade
Countries which reported cases
Infectiousness
Limited
Up to 7 generations
Case fatality ratio
Up to 6%
Up to 11%


3. TÁC NHÂN
Bộ gen DNA chuỗi kép khoảng 197kb với hàm lượng Guanin-Cytosine (GC) trung bình là 33%. Chứa 190 trình tự mã hoá. Bộ gen chứa 1 đoạn gen lặp lại song song → Khó tái tạo chính xác
Chủng tại UK 2022 chứa 48 đột biến đơn lẻ trong bộ gen so với năm 2018. (27 đột biến "im lặng" vì ko thay đổi protein nào)
Phân loại đột biến theo mức độ ưu tiên: thấp -trung bình- cao → QUAN TRỌNG: hiện tại chúng ta không thể dự đoán được a/h các đột biến đơn lẻ so với đột biến kết hợp toàn bộ gen!


Monkeypox Transmission Cycle in Central Africa
Bushmeat hunting
Humans
Other humans


Monkeypox transmission – an overview
Primary infection
Animal ➡ human
Secondary infection
human ➡ human


KHẢ NĂNG LÂY NHIỄM
Attack rate: 10-15% (much lower than smallpox-60% (30-80)
Động vật – người:
Chạm/bị ĐV có vú nhiễm bệnh cắn-cào
Chạm vào SP/đồ vật của ĐV bệnh (da sống, thịt, chỗ ở…)
Người – người:
Tiếp xúc gần*/QHTD**
Chạm vào phát ban/vảy ban của bệnh nhân
Chạm vào các đồ vật bị ô nhiễm như khăn trải giường, quần áo/thiết bị y tế BN đã sử dụng
Có thể truyền qua nhau thai từ mẹ-con


KHẢ NĂNG LÂY NHIỄM
MONKEYPOX
HOW IT SPREADS


4. HỆ THỐNG GSB
1. Hệ thống GSB & Đáp ứng + WHO
Vùng lưu hành dịch (endemic)
Quốc gia mới (non-endemic)
Việt Nam
2. Định nghĩa TH bệnh
TH bệnh nghi ngờ (G/S)
TH bệnh có thể
TH bệnh xác định
3. Định nghĩa ổ dịch

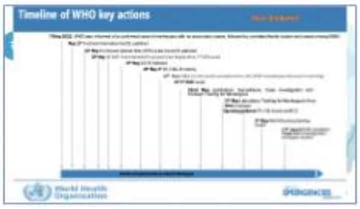

MỤC TIÊU GIÁM SÁT
Mục tiêu chung của việc giám sát, điều tra ca bệnh và truy tìm mối liên hệ trong bối cảnh này là phá vỡ các chuỗi lây truyền từ người sang người và ngăn chặn sự bùng phát.
Các mục tiêu chính:
Xác định nhanh chóng ca/chùm ca
→ cung cấp dịch vụ chăm sóc lâm sàng tối ưu
→ cách ly → ngăn ngừa lây thêm
Xác định và quản lý ca tiếp xúc
Bảo vệ nhân viên y tế tuyến đầu
Điều chỉnh các biện pháp KSPNBT hiệu quả


Monkeypox surveillance
Mapping person, place and time
Detailed case investigation
Specimen collection
Primary / co-primary cases
Secondary cases


HỆ THỐNG GIÁM SÁT TẠI CHÂU PHI
Endemic
WHO & các nước lưu hành bệnh phối hợp triển khai hệ thống giám sát "Integrated Disease Surveillance and Response"
Outbreaks and Emergencies Bulletin, Week 23 : 30 May - 5 June 2022


HỆ THỐNG GIÁM SÁT TẠI CHÂU PHI
Endemic


Endemic
Monkeypox


Timeline of WHO key actions


Non-Endemic WHO
June 25
July 21 - 23

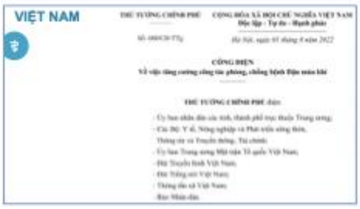

Non-Endemic
WHO_update on 20Jun2022

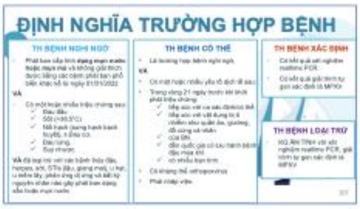

Ngày 23/07/2022
WHO: "a public health emergency"
Temporary Recommendations issued by the WHO Director-General


WHO KHUYẾN CÁO


Case report form (CRF)- WHO
INTRODUCTION


VIỆT NAM
BỘ Y TẾ


VIỆT NAM
CÔNG ĐIỆN


ĐỊNH NGHĨA TRƯỜNG HỢP BỆNH
TH BỆNH NGHI NGỜ
TH BỆNH CÓ THỂ
TH BỆNH XÁC ĐỊNH
TH BỆNH LOẠI TRỪ

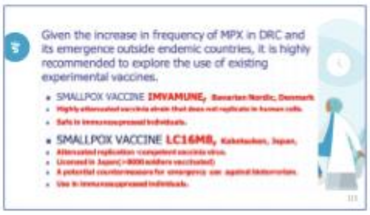

NGƯỜI TIẾP XÚC GẦN


QUY TRÌNH GIÁM SÁT


ĐỊNH NGHĨA Ổ DỊCH
Định nghĩa ổ dịch: 1 TH bệnh xác định (ngoài vùng lưu hành)


5. CÁC BIỆN PHÁP PHÒNG CHỐNG
1. Đặc hiệu
2. Không đặc hiệu
3. Kiểm dịch y tế biên giới
4. One health
5. Tập huấn, truyền thông, sẵn sàng nguồn lực


PHÒNG ĐẶC HIỆU: VẮC-XIN


Given the increase in frequency of MPX in DRC and its emergence outside endemic countries, it is highly recommended to explore the use of existing experimental vaccines.
SMALLPOX VACCINE IMVAMUNE
SMALLPOX VACCINE LC16M8


Vaccines and immunization for monkeypox


CÁC NGUYÊN TẮC SỬ DỤNG VẮC XIN
Hướng dẫn sử dụng vắc xin tạm thời của WHO nên được phổ biến rộng rãi để xây dựng chính sách, chiến lược tiêm nên bao gồm các nhóm nguy cơ khác nhau, các loại vắc xin (tránh cụ thể hoá sản phẩm)
Năm 2013, WHO đã đưa ra khuyến nghị sử dụng vx đậu mùa. Các khuyến nghị bổ sung tạm thời từ ban thư ký WHO chỉ áp dụng cho phòng ngừa và kiểm soát đậu mùa khỉ.
Vaccines and immunization for monkeypox


Thanh toán bệnh đậu mùa 1980- và việc ngừng tiêm chủng
Chủng ngừa bệnh đậu mùa đã được chứng minh qua một số nghiên cứu trước đây tại Châu Phi là có hiệu quả khoảng 85% trong việc ngăn ngừa bệnh đậu mùa khỉ. Do đó, việc tiêm phòng đậu mùa trước có thể khiến bệnh nhẹ hơn. Mặc dù trước đây việc tiêm phòng bệnh đậu mùa có tác dụng bảo vệ nhưng ngày nay những người dưới 40 đến 50 tuổi (tùy thuộc vào quốc gia) có thể dễ bị bệnh đậu mùa hơn do các chiến dịch tiêm phòng bệnh đậu mùa trên toàn cầu đã ngừng hoạt động sau khi loại trừ dịch bệnh.


PHÒNG KHÔNG ĐẶC HIỆU


KIỂM DỊCH Y TẾ BIÊN GIỚI
Giám sát nhập cảnh
Khai báo y tế: NĐ 89/NĐ-CP, 25/6/2018
Cách ly
NĐ 101/2010/NĐ-CP, 30/9/2010


ONE HEALTH


TẬP HUẤN – TRUYỀN THÔNG & SẴN SÀNG VỀ NGUỒN LỰC


TRUYỀN THÔNG
Raising awareness of monkeypox – what to know?
Avoid unprotected close contact with infected people
Wash hands frequently with soap and water, especially after caring for or visiting sick people
Do not share bedding, clothing, towels or utensils with sick people
Use personal protective equipment (PPE) when caring for patients
Avoid contact with wild animals specially those found sick or dead
Isolate infected patients in hospital or at home
Prevention of monkeypox
Raising awareness
Vaccinia vaccine


MỘT SỐ CÂU HỎI NGHIÊN CỨU
Priority research questions
The following are some of the research questions that will help in the disease control
What signs and symptoms can confirm the clinical diagnosis of Monkeypox?
What clinical findings (signs, symptoms, biomarkers, and imaging) are associated with a worse prognosis in ?
What is the best strategy to achieve treatment goals in patients with non-communicable diseases (NCDs) during the Monkeypox pandemic?
What are the short, mid-, and long-term post-infectious sequelae of Monkeypox?
What is the Monkeypox Infection Fatality Rate in low and middle countries, including stratification by age?
What is the excess mortality of non- Monkeypox in low- and middle-income countries (LMIC) during the pandemic?


TÀI LIỆU THAM KHẢO CHÍNH
https:/ / www.who.int/ health-topics/ monkeypox#tab=tab_1
OpenWHO.org
https:/ / worldhealthorg.shinyapps.io/ mpx_global/_w_78e9e141/ #section-fns
https:/ / www.paho.org/ en/ monkeypox
https:/ / www.cdc.gov/ poxvirus/ monkeypox/ response/ 2022/ world-map.html.
https:/ / www.monkeypox.global.health
https:/ / github.com/ globaldothealth/ monkeypox
https:/ / www.ecdc.europa.eu/ en/ news-events/ epidemiological-update-monkeypox-multi-country-outbreak-15-June
https:/ / monkeypoxreport.ecdc.europa.eu
https:/ / www.paho.org/ en/ documents/ weekly-situation-report-monkeypox-multi-country-outbreak-response-region-americas-5
https:/ / shiny.pahobra.org/ monkeypox/
https:/ / www.thelancet.com/ journals/ laninf/ article/ PIIS1473-3099(22)00359-0/ fulltext
Review in 1973, USA:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC413801/pdf/bactrev00040-0009.pdf


THANKS!
Any questions?
You can find me at:
Huyen.Nguyen@anu.edu.au
125

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Chapter 2. Investigate an acute public health problem

An outbreak of Avian Influenza A/H5N1 in human in Phu Tho province, Vietnam, 2022

List of Abbreviations – Chapter 2

ANU	Australian National University
MAE	Master of Applied Epidemiology Program
NIHE	National Institute of Hygiene and Epidemiology
COVID-19	Coronavirus Disease 2019
RRT	Rapid response team
WHO	World Health Organization
EPI	Expanded Programme on Immunization
AI	Avian Influenza
OpenWHO	Open World Health Organization
LPAI	Low pathogenic avian influenza
HPAI	High pathogenic avian influenza
EPI-WIN	WHO's Information Network for Epidemics
CFR	Case fatality rate
MARD	The Ministry of Agriculture and Rural Development
ILI	Influenza-like-illness
SVP	Severe Viral Pneumania
SARI	Severed Acute Respiratory Infection
PCR	Polymerase chain reaction
NIC	National Influenza Centres
US CDC	US's Centers for Disease Control and Prevention
ECDC	European Centre for Disease Prevention and Control
GISRS	Global Influenza Surveillance and Response System

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2.1 Prologue

2.1.1 Rationale

This chapter presents a report of an outbreak of avian influenza A in a human in Vietnam, 2022. This outbreak investigation fulfills a competency requirement of the MAE program.

The investigation was led by NIHE in collaboration with the Department of Animal Health, Ministry of Agriculture and Rural Development, Center for Disease Control of Phu Tho Province, Regional Sub-Department of Animal Health 1, Phu Tho Provincial Sub-Department of Animal Health, Dong Ba district health center and Dong Ba district authorities.

I received permission from my field supervisors, Assoc.Prof. Pham Quang Thai, Dr. Nguyen Cong Khanh and Assoc.Prof. Tran Nhu Duong - Deputy director of the NIHE to join the investigation team for my learning purposes.

2.1.2 My role

For this outbreak, we worked with the other staff to establish a contact tracing team to investigate the outbreak. I was assigned to do the following tasks:

- Reviewing the avian influenza status in humans globally
- Contribute ing to composing investigation documents
- Interviewing the suspected cases and close contacts of the confirmed case in the field to construct possible transmission chain of the outbreak
- Creating a data entry frame using Excel software, undertaking data entry and managing the outbreak's epidemiological dataset.
- Performing data analysis
- Writing the outbreak report

2.2 Achievements

This chapter consists of a manuscript I wrote during my time as a Master of Applied Epidemiology (MAE) scholar. My academic supervisor and two field supervisors were involved in the process, and guided me throughout the submission.

I presented this project at two international conferences in 2023, one in Perth, Western Australia, and the other in Vietnam (the presentations are included in Appendix 2.2). Additionaly, I was honored to receive the Third Place Award for Most Outstanding Presentation at The 13th International Conference on Public Health among the Greater Mekong Subregion Countries 2023 (GMS13) in Hue, Vietnam (photos of the award ceremony are included below, Figure 2.1).

Figure 2.1. Photos of me presenting on stage and receiving the award in the conference in Vietnam

2.3 Lessons learned

As a master student of applied Epidemiology involved in the response team for this H5N1 human outbreak in Vietnam, several valuable lessons I were gleaned from the experience, shaping my understanding of crisis management and public health interventions.

Firstly, the significance of real-world application of epidemiological principles became evident. The outbreak provided an opportunity to witness the practical implementation of the 10-step outbreak investigation, surveillance, contact tracing, and data analysis techniques, solidifying my knowledge and skills in these areas. Furthermore, I've self-studied about zoonoses, Avian Influenza disease through resources of World Health Organization (WHO) platforms to enhance my knowlege of this disease during and after the outbreak:

- WHO's Information Network for Epidemics (EPI-WIN) webinar: *The current global influenza outbreak: what we are doing and what it means for pandemic influenza* (18 January 2023) https://www.who.int/news-room/events/detail/2023/01/18/default-calendar/epi-win-webinar-the-current-global-influenza-outbreak-what-we-are-doing-and-what-it-means-for-pandemic-influenza

- WHO's EPI-WIN webinar: *Influenza – Avian Influenza H5: its evolution and associated risk* (29 March 2023) https://www.who.int/news-room/events/detail/2023/03/29/default-calendar/epi-win-webinar-influenza-avian-influenza-h5-its-evolution-and-associated-risk
- OpenWHO, Avian and other zoonotic influenza: Introduction https://openwho.org/courses/avian-and-other-zoonotic-influenza-introduction/
- OpenWHO, Navigating the Tripartite Zoonoses Guide (TZG): A training for advocates and implementers https://openwho.org/courses/tripartite-zoonoses-guide/items/18lXOMCLdJUD6jPzkHcDvd

Secondly, the importance of collaboration and teamwork was highlighted. An outbreak usually requires a rapid response. Working alongside experts from diverse disciplines, such as medical professionals, veterinarians, and public health officials, emphasized the value of effective communication, coordination, and interdisciplinary collaboration in mounting a successful response. Moreover, providing clear instructions to team members can decrease the likelihood of overlooking information, which proves beneficial in interpreting and drawing conclusions from the data.

Thirdly, a valuable lesson learned is the importance of effective communication with the community about what actions to take when suspected symptoms of Avian Influenza (AI) in humans and/or animals are detected. This is especially crucial as we faced challenges in collecting specimens due to premature culling of remaining poultry by the patient's family before investigation day. The experience shed light on the complexities of risk communication and the need for clear, concise, and culturally appropriate messaging to address public concerns, mitigate panic, and promote adherence to preventive measures.

Additionally, an other important lesson learned is the significance of avoiding the consumption of raw or undercooked animal products, particularly infected live or dead poultry, to prevent infection and potential spread of diseases like Avian Influenza.

Finally, the experience reinforced the vital role of regularly sharing and updating information on human epidemiology, animal epidemiology, and laboratory findings of Avian Influenza A/H5N1 from relevant stakeholders. This evidence-based comprehensive approach provides a holistic view of the epidemic, facilitating informed decision-making and effective control measures.

Armed with these lessons, I am better equipped and feel confidently to contribute to future outbreak responses.

2.4 Public health impact

The response to the single H5N1 human case outbreak in Vietnam in 2022 had a notable public health impact. Despite the limited scope, the response team's swift action and comprehensive approach played a vital role in preventing further transmission and protecting public health. Through contact tracing and isolation measures, potential sources of infection were identified and contained, minimizing the risk of secondary cases. Rigorous surveillance and monitoring ensured early detection of any potential spread, enabling prompt interventions. Public health education campaigns informed the population about the risks associated with Avian Influenza, emphasizing preventive measures and promoting vigilance. The response also served as a valuable opportunity for capacity building, allowing healthcare professionals to enhance their knowledge and skills in managing and responding to infectious disease outbreaks. While the scale of the outbreak was small, the response demonstrated the effectiveness of targeted and coordinated public health interventions in minimizing the impact of isolated cases and safeguarding population health. This project highlights its value as an analysis method for field epidemiologists in response to the Avian Influenza in human.

2.5 Ackowledgements

I would like to acknowledge and thank the following the institutions, organisations and individuals for their guidance and assistance with the investigation:

- Vietnam National Institute of Hygiene and Epidemiology (NIHE)
- Center for Disease Control of Phu Tho Province
- Department of Animal Health, Ministry of Agriculture and Rural Development

- Regional Sub-Department of Animal Health 1
- Phu Tho Provincial Sub-Department of Animal Health
- Dong Ba district authorities
- Trainees of Field Epidemiology Training Program at NIHE.
- Other stakeholders.
- Supervisory team:
    + Assoc.Prof. Samantha Colquhoun
    + Assoc.Prof. Pham Quang Thai
    + Dr. Florian Vogt
    + Dr. Nguyen Cong Khanh

2.6 Master of Philosophy in Applied Epidemiology core requirements

✓ Investigate an acute public health problem or threat

✓ Write a manuscript (Appendix 2.1)

✓ Prepare an abstract and oral presentation of the project at a national or international scientific conference (Appendix 2.2)

- ***Huyen Thi Nguyen****, Khanh Cong Nguyen, Tu Huy Ngo, Bich-Hanh Thi Cu, Viet Phong Nguyen, Hien Thi Nguyen, Trang Thu Vu, Nghia Duy Ngu, Duong Nhu Tran, Hung Manh Vu, Diep Thi Nguyen, Oanh Trong Nguyen, Viet Hai Ha, Duc Anh Dang, Florian Vogt, Samantha Colquhoun, Thai Quang Pham; "****Lessons learned from an Avian Influenza Outbreak in Vietnam, 2022****". Poster oral presentation (6 minutes),* ***Communicable Diseases and Immunisation Conference 2023 (CDIC2023)****,* ***19 – 21 June 2023 in Perth, Western Australia.***

- ***Huyen Thi Nguyen****, Khanh Cong Nguyen, Tu Huy Ngo, Bich-Hanh Thi Cu, Viet Phong Nguyen, Hien Thi Nguyen, Trang Thu Vu, Nghia Duy Ngu, Duong Nhu Tran, Hung Manh Vu, Diep Thi Nguyen, Oanh Trong Nguyen, Viet Hai Ha, Duc Anh Dang, Florian Vogt, Samantha Colquhoun, Thai Quang Pham; "****Lessons learned from an Avian Influenza Outbreak in Vietnam, 2022". Long oral presentation (8 minutes), The 13th International Conference on Public Health among the Greater Mekong Subregion countries 2023 (GMS-13), 01 – 02 July 2023 in Hue, Vietnam.***

2.7 Abstract

Background:

Inter-sectoral coordination plays a pivotal role in investigation and control of Avian Influenza outbreaks in humans. An outbreak of Avian Influenza A (H5N1) in humans in Phu Tho, Vietnam, occurred in 2022. The outbreak was quickly investigated and brought under control.

Methods:

We responded to an outbreak of H5N1 following the report of single positive laboratory result in October 2022. Data were sourced from hospital-based platforms and through field investigation in the community where the index case resided. Close contacts were identified, health checks and swab samples were undertaken.

Results:

On 05 October 2022, a four-year-old patient was identified with cough, fever, fatigue, and jaundice. She was hospitalized on 08 October at the National Children's Hospital in Hanoi and discharged on 30 October in a stable condition. On 17 October, the laboratory confirmed Avian Influenza A/H5. A rapid response team (RRT) from the National Institute of Hygiene and Epidemiology, the Animal Health Department and local rapid response team undertook a field investigation. The investigation was expanded to the surrounding community, and disinfection of the environment surrounding the affected area was completed. The patient's family raised 18 backyard poultry; some had died and were cooked for food the day before onset. Samples were collected from 65 close contacts, the field team undertook daily health monitoring until the 21st day of the outbreak. Environmental samples at the patient's house and pooled samples from poultry from four households nearby, were collected, all were negative for Avian Influenza.

Conclusion:

Early detection of Avian Influenza in humans at the provincial and community levels in Vietnam is challenging. Human activities and the natural reservoir of influenza viruses have a strong link via domestic birds and pigs. Well-coordinated inter-sectoral coordination is essential, especially between the health sector and the veterinary sector.

Keywords:

Avian influenza in human, H5N1, infection transmission, outbreaks, control.

2.8 Appendices

2.8.1 Appendix 2.1. Manuscript

Lessons learned from an Avian Influenza Outbreak in Vietnam, 2022

Introduction

Avian Influenza A/H5N1

Avian influenza, commonly known as bird flu, is a disease resulting from the infection of avian (bird) influenza (flu) type A viruses. These viruses primarily circulate among wild aquatic birds globally which are usually asymptomatic carriers and can also infect domestic poultry and other bird and animal species (chickens, ducks, turkeys). In poultry, avian influenza can manifest in either low pathogenicity (LPAI), leading to mild disease, or high pathogenicity (HPAI), causing severe illness and fatalities. The virus comprises various strains such as H5N1, H5N6 or H7N9. Some LPAI viruses can mutate and become HPAI viruses [1, 2].

These viruses can occasionally infect humans through direct or indirect contact from sick or health-appearing animals or contaminated environments (live poultry markets), have the potential to cause a range of illnesses in humans, from mild to severe, and even fatal cases. Initial symptoms of A(H5) virus infection in people include fever 38°C and cough. Other symptoms related to respiratory symptoms (e.g. dyspnoea) and non-respiratory symptoms include diarrhoea, vomiting & abdominal pain. Complications can include hypoxaemia, multiple organ dysfunction and secondary bacterial infections. Higher case fatality rate than seasonal influenza. Influenza A (H5N1), incubation period is 2-5 days, can be up to 17 days, longer than seasonal influenza (2 days) [2].

People most at-risk are those that have direct or indirect contact through their occupation (e.g. farmers, people saling birds at markets, slaughtering, defeathering, handling carcasses and preparing poultry for consumption). Some humans have been infected from visiting live animal markets. There is no evidence that the AI A/H5N1 can be spread to people through properly cooked food. There is “no evidence of sustained human-to-human transmission" of the virus [1, 3, 4].

The first notified outbreak of avian influenza in humans was avian influenza A(H5N1) in 1997 in poultry in Hong Kong, China. Subsequently, since 2003, these and other influenza viruses have extended their spread from Asia to Europe and Africa. In 2013, human infections with influenza A(H7N9) were reported in China [1, 4, 5]. H5N1 pathogenicity is gradually continuing to rise in endemic areas, but the avian influenza disease situation in farmed birds is being held in check by vaccination. As of May 2023, the WHO reported a total of 873 confirmed human cases with A(H5N1) viruses from 23 countries, including 458 deaths (CFR 52%) [1].

Since 1952, global influenza surveillance has been carried out via the World Health Organization's Global Influenza Surveillance and Response System (GISRS) (Figure 2.2). This system relies on efficient collaboration and the exchange of viruses, data, and benefits, built on the commitment of Member States to a global public health model [6].

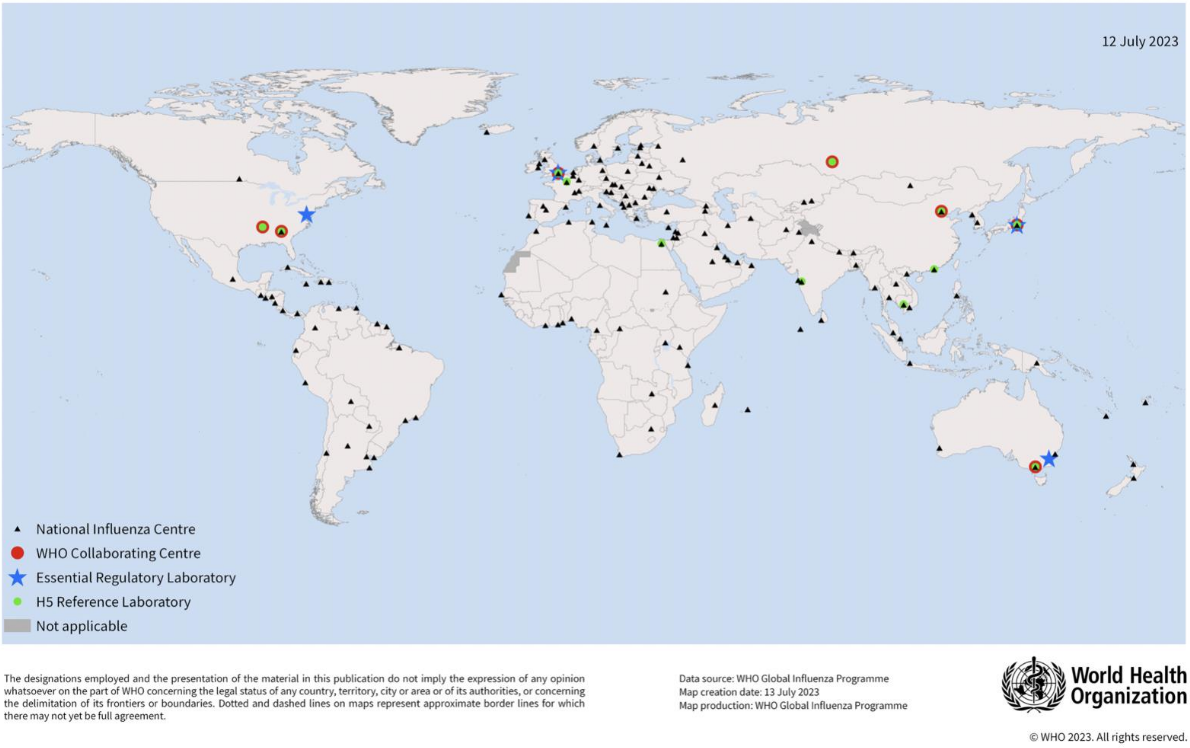

Figure 2.2. WHO Global Influenza Surveillance and Response System (GISRS)

Where outbreaks occur, it is often the policy to cull all poultry, whether infected or healthy, to contain the spread of avian influenza. This leads to significant financial losses for farmers and has a lasting impact on their means of living. In countries experiencing outbreaks, the impact on poultry has had detrimental effects on various aspects. These include livelihoods, with sickness, death, and loss of income; the economy, and international trade, especially within the poultry sector.

Avian Influenza A/H5N1 in Vietnam

In Vietnam, AI A/H5N1 has been a significant issue since its outbreak in poultry and in human in 2003. Vietnam has two National Influenza Centres (NICs) located at the NIHE and the Pasteur Institute in Ho Chi Minh City. However, there is no WHO H5 Reference Laboratory established in the country [6]. These NICs is accredited by the WHO, and its influenza testing results are accepted as confirmatory within the WHO Global Influenza Surveillance and Response System (GISRS) framework.

Vietnam's geographical location, dense poultry population, and proximity to other affected countries have made it particularly vulnerable to the virus. The illegal poultry trade along the Vietnam-China border adds to the challenges. As an agricultural country with a tradition of small-scale household farming for self-sufficiency, Vietnam allows poultry to roam freely and is not commonly vaccinated. In fact, most animal holdings are small with inadequate biosecurity measures. Their proximity to residential areas makes it challenging to implement biosecurity and disease control measures effectively. This practice has raised concerns about disease control and management in the poultry population [7, 8].

Despite efforts, avian influenza outbreaks still occur sporadically in Vietnamese provinces. The Ministry of Agriculture and Rural Development (MARD) has classified 399 districts in Vietnam as high-risk areas for bird flu outbreaks, with an additional 314 districts considered low-risk. A/H5N1 is one of three strains of HPAI viruses (with A/H5N6, and A/H5N8) is circulating in the country. Since mid-June 2021, A/H5N8 has emerged in Vietnam and spread to 10 provinces and cities, leading to the culling of more than 23,000 birds. These outbreaks resulted in extensive poultry deaths, leading to substantial economic losses for the agricultural sector [8].

The most recent reported cases of avian influenza in Vietnam date back to 2014 in Dong Thap, the southern province. In Phu Tho province where this outbreak occurred, two human cases of H5N1 were recorded : one case in 2005 in Thanh Ba district and another case in 2008 in Yen Lap district. Avian influenza A/H5N1 has presented a significant risk to public health in Vietnam, with 128 cases of human infection recorded including this outbreak, of which 64 resulted in fatalities (50%) to date (Figure 2.3). This has placed Vietnam among the top 3 countries worldwide affected by AI A/H5N1 (after Egypt and Indonesia) [9].

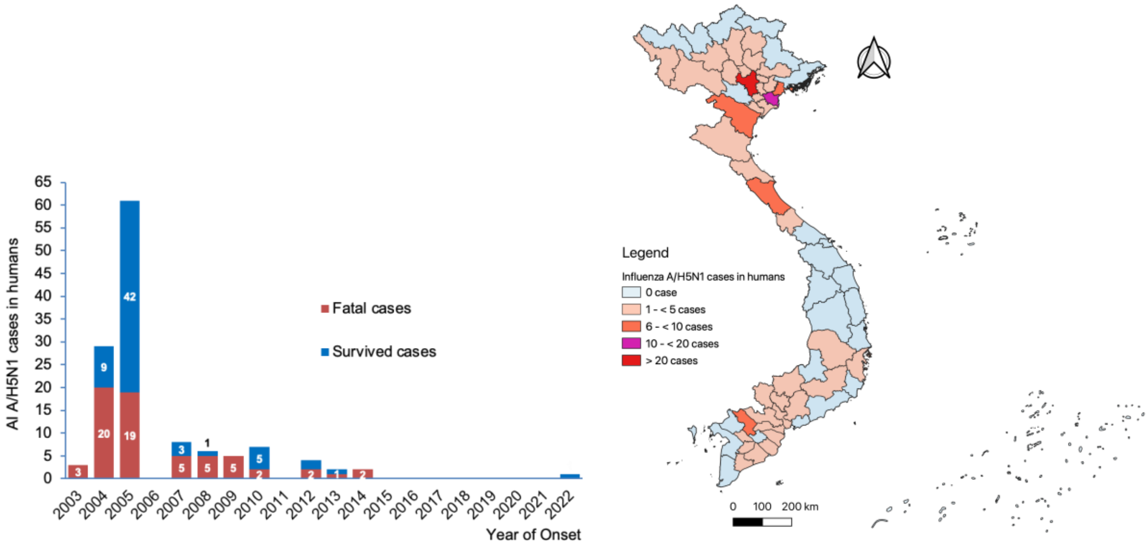

Figure 2.3. Distribution of AI A/H5N1 cases in humans in Vietnam by years and locations during the period of 20 years, 2003 – 2022

The Ministry of Health classifies avian influenza A/H5N1 as a Group A infectious disease under the Law on Prevention and Control of Infectious Diseases. Group A diseases are considered dangerous, with a high fatality rate, and require immediate response within 24 hours of detection [10].

Since 2003, various surveillance systems have been established in Vietnam to promptly detect suspected cases of avian influenza in humans: **Joint outbreak investigation** once confirmation of Avian Influenza in human and/or animal: **Influenza-like-illness (ILI)** syndromic surveillance of ILI for close contacts in human and animal. **Severed Viral Pneumonia (SVP)** in all hospitals: national wide event-based surveillance. **Severed Acute Respiratory Infection (SARI):** Sentinel surveillance to monitor the activities of influenza viruses. **Laboratory surveillance:** identify the subtypes of influenza positive cases and sequencing the avian influenza in human and animal.

Identification of the outbreak

On 17th October, a laboratory-confirmed test result (PCR Real time) from the National Institute of Hygiene and Epidemiology (NIHE), which is the National Influenza Centre (NIC) in Vietnam, confirmed avian influenza A/H5 in a 4-year-old girl.

The patient's date of birth was 23/04/2018 and her permanent address was in Zone 10, Dong Thanh commune, Thanh Ba district, Phu Tho province. She had no history of comorbidities or recent travel. An outbreak investigation was subsequently initiated and a rapid response team was formed to investigate and control the outbreak in the community.

Our first aim was to respond rapidly to the situation and swiftly implement control measures to contain the outbreak. Immediately notifying the test results to the National Children's Hospital and the Phu Tho Provincial Center for Disease Control. Submitting a rapid report to the General Department of Preventive Medicine and informing the Department of Health and the Phu Tho Provincial Center for Disease Control. Reporting the case to the Department of Animal Health, Ministry of Agriculture and Rural Development, to coordinate the investigation and outbreak response in the field the following day (deploying at least one epidemiologist and one laboratory staff member). Coordinate with the Phu Tho Provincial Department of Health to focus on risk communication, infection prevention, and control measures. Communication targeted the affected family, community members, healthcare workers (HCWs), and teachers. The key messages focused on reducing contact with potentially infected poultry, recognizing symptoms of avian influenza, and proper actions to take if symptoms developed. Communication was conducted through direct meetings, local broadcasting, posters, and guidance provided during field visits. These activities were implemented immediately after the case was confirmed, and throughout the outbreak period to ensure proper understanding. We conducted assessments to determine the availability of personal protective equipment (PPE) and checked that HCWs understood and followed the proper procedures for dealing with suspected avian influenza cases. At hospitals, we ensured the use of standard and contact precautions based on the exposure risks. Affected family members and investigation team members were provided with masks and gloves when handling potentially infectious material. For personnel collecting poultry and environmental samples, PPE was used throughout the entire process.

Secondly to proactively identify cases, collecting samples from both human patients and animals to assess the extent of the outbreak. Thirdly to pinpoint the root cause of the outbreak, whether it originated in animals or humans. Finally, to reinforce and bolster surveillance and reporting systems at every administrative level in Phu Tho province. By pursuing these objectives, the investigation aimed to gain a comprehensive understanding of the outbreak, manage its impact effectively, and enhance the region's readiness for future outbreaks.

Methodology

We responded to an outbreak of H5N1 following the report of single positive laboratory on 17th October 2022. The investigation finished on 30 October 2022 after no more cases were reported. Data were sourced from hospital-based platforms and through field investigation in the community where the index case resided. Close contacts were identified, health checks and swab samples were undertaken.

In preparation for the field trip as part of our outbreak response, we took careful steps to ensure a well-organized and efficient operation. Firstly, we meticulously organized all legal documents to facilitate our activities within the affected area. Our team included skilled personnel such as epidemiologists, laboratory experts, and veterinarians, each playing a vital role in the investigation process. To effectively gather crucial data, we readied the necessary sampling tools and investigation forms. We secured a suitable car and a qualified driver to ensure the team's mobility and swift response throughout the mission.

Execute control and preventation activities based on guidelines and legal documents of the Ministry of Health in Vietnam: Pursuant to

- *The Law on Prevention and Control of Infectious Diseases dated November 21, 2007;*
- *Circular No. 54/2015/TT-BYT dated December 28, 2015 providing guidance on reporting and declaration of infectious diseases and epidemics*
- *Circular No. 15/2014/TT-BYT dated May 15, 2014 providing guidance on reporting and declaration of health quarantine activities*
- *Circular No. 17/2019/TT-BYT dated July 17, 2019 providing instructions about communicable disease surveilance and response*
- *Joint circular No. 16/2013/TTLT-BYT-BNN&PTNT dated May 27, 2013 providing guidance on cooperation between animal health sector and human health sector on prevention and control infectious diseases from animal to human.*

Setting up these following surveillance methods in Phu Tho province for monitoring and control of the H5N1 outbreak.

1. **Influenza-like Illness (ILI) Surveillance at Commune Health Centers:** to allow for early detection of potential H5N1 cases in the community. Patients presenting with ILI symptoms such as fever, cough, and sore throat were screened and checked.

2. **Severe Acute Respiratory Infections (SARI) and Severe Viral Pneumonia (SVP) Surveillance at District and Provincial Hospitals:** to identify severe cases that require closely monitored to ensure appropriate treatment and containment measures.

3. **Surveillance of Sick Poultry:** to monitor bird populations, especially in the affected area (Dong Ba district). The surveillance involves reporting and testing of sick or dead birds, ensuring rapid response to potential outbreaks among poultry, and implementing control measures to prevent transmission to humans.

Case definition, the outbreak definition and case finding

The following definitions were for the purpose of investigations of confirmed cases, probable cases, and cases of Avian Influenza A virus infection under investigation in this outbreak. We developed these definitions based on surveillance guidelines from the WHO [11], the US CDC [4], the ECDC [3], and the Vietnam Ministry of Health [10].

Case definition:

We defined a person as a case if he/she was a resident in the affected facility, having the following criteria, in the period between 19 September and 29 October 2022.

Confirmed case:

- Any person with a positive test result for influenza A/H5 or A/H5N1 performed by a National Reference Laboratory (the NIHE laboratory or PI HCMC).
    + Polymerase chain reaction (PCR), or
    + Virus isolation, or
    + Paired acute and convalescent serologic tests.
        - An antibody titre in a single serum is often not enough to confirm a recent infection. Two samples needed.

Probable case:

- Any person with a positive test for influenza A/H5 or A/H5N1 performed by a laboratory which is not a National Reference Laboratory.

Suspected case (or Case under investigation):

- Any person presenting with unexplained acute lower respiratory illness with fever (>38°C) and cough, shortness of breath or difficulty in breathing.

  AND

- One or more of the following exposures in the seven days prior to the onset of the symptom:
    + (a) Close contact (within 1 metre) with a person (e.g. caring for, speaking with or touching) who is a suspected, probable, or confirmed H5N1 case;
    + (b) Exposure (e.g. handling, slaughtering, plucking, butchering, preparing for consumption) to poultry or wild birds or their remains or to environments contaminated by their faeces in an area where H5N1 infections in animals or humans have been suspected or confirmed in the last month;
    + (c) Consumption of raw or undercooked poultry products in an area where H5N1 infections in animals or humans have been suspected or confirmed in the last month;

+ (d) Close contact with a confirmed H5N1 infected animal other than poultry or wild birds (e.g. cat or pig);
+ (e) Handling samples (animal or human) suspected of containing H5N1 virus in a laboratory or other setting.

- Monitoring period: from the onset until the end of the outbreak.

Close contact:

- Any person having been in close contact (within 1 metre) with the following, within the past 14 days:
  + An animal with confirmed A/H5N1 infection; or
  + A confirmed human case

The outbreak definition:

An outbreak was established when there is one or more patients diagnosed with laboratory confirmed infection of Avian Influenza A (H5N1) virus.

Ending the outbreak:

- After 21 days without recording any new human cases.
- High-risk individuals in the affected area test negative for the virus.
- The surrounding environment has been thoroughly disinfected using Chloramine B or other disinfectants.

Epidemiology investigation

An investigating document form for case finding was created to include case identification and contacts with demographics, symptoms, exposures anddata with time, place and person indentified (Table 2.1)

Table 2.1. *Questionnaire form for investigating the close contacts in the field*

Case ID	Onset date & time	Town of residence	Sex	Age (years)	Hospitalised	Disease type	Subtype

Data from the paper-based questionnaire were entered into Microsoft Excel. Preliminary data cleaning was performed, including renaming variables and identifying and removing duplicates.

Environmental and animal investigation

The environmental and animal investigation was led by the Animal Health Department, The Ministry of Agriculture and Rural Development (MARD). Veterinary/animal epidemiologists inspected the farming premises and households nearby on 17-18 October 2022, including the backyards and handwashing and food storage facilities.

Laboratory investigation

All cases in humans that met the above definition criteria were sampled and sent to the NIHE for testing the Avian Influenza virus type A/H5N1. The specimens collected were nose and throat swabs, obtained by provincial CDC laboratory staff, as early as possible after the cases were identified according to the specified criteria. Test results were read and reported by the WHO-accredited laboratory at NIHE. All environmental samples and poultry samples were sent to the provincial veterinary testing laboratory to test for Avian Influenza virus.

The investigation team also assessed the testing capacity in both human and animal fields. We evaluated the available resources and capacity for conducting tests in healthcare facilities for humans and animal health organizations. In the context of this outbreak, should it escalate, it is crucial to ensure accurate and efficient testing. The assessment involved confirming that laboratories possessed the necessary equipment, trained personnel, and sufficient supplies for testing both human and animal samples. It also ensured that the testing procedures followed established protocols and guidelines, enabling prompt and accurate diagnosis of cases in both humans and animals during the outbreak response.

Develop hypotheses

The index human case of avian influenza A/H5N1 was likely caused by exposure to the H5N1 virus, originating from infected poultry kept at the patient's household or that of nearby neighbors. The mode of transmission is hypothesized to be animal-to-human, potentially through direct contact with infected poultry or their secretions during activities such as raising, handling, slaughtering, or food preparation, without the use of appropriate personal protective equipment. The suspected vehicle is contaminated poultry meat or surfaces. Based on the timing of symptom onset, the probable exposure period was within the 17 days prior to illness onset, during which the patient or household members may have contacted, handled, or consumed sick or dead poultry. People at risk include household members and others with direct exposure to the same poultry during that time.

Ethical approval

Ethics review of this outbreak investigation was waived by the Australian National University Human Research Ethics Committee under the protocol number 2017/909.

Ethical approval in Vietnam was not required due to the need for emergency response.

Results

Epidemiological and Laboratory Findings

Administrative structure of the affected area:

Dong Thanh commune is a lowland mountainous area located in the southeast of Thanh Ba district, Phu Tho province. It is situated 8 km away from Thanh Ba town and 40 km away from Phu Tho city. The commune consists of 17 residential zones with a population of 8,200 people belonging to 2,032 households. Zone 10 is one of the residential zones, comprising 113 households with 405 people. The patient's family residence is located at the end of this area and relatively isolated from the surrounding households.

Index case:

On 5th October (Figure 2.4), a four-year-old girl, residing in Zone 10, Dong Thanh commune, Thanh Ba district, Phu Tho province, developed symptoms of cough and fever (38,5^{o}C) and the family opted for self-care at home. However, her condition worsened, and on 7th October, she was admitted to a provincial hospital presenting with cough, fever, fatigue, and jaundice. The initial diagnosis suspected an unknown liver disease, and COVID-19 was ruled out.

Recognizing the severity of her illness, she was transferred to the National Hospital of Pediatrics in Hanoi on 8th October. Here, she was diagnosed with acute liver failure – acute kidney failure/septic shock/multiple organ failure, respiratory failure, endotracheal intubation at the Internal Medicine Intensive Care Unit. On the same day, as part of rapid diagnostic testing to support early diagnosis and treatment, a respiratory sample was collected and tested at the NCH laboratory, which confirmed the presence of Influenza A/H5. However, given the concurrent diagnosis of multiple severe conditions, the hospital prioritized clinical management and did not immediately notify the National Institute of Hygiene and Epidemiology (NIHE) or conduct further confirmatory testing. As the patient's condition worsened, on 14 October, another tracheal aspirate sample was collected and sent to NIHE for confirmatory diagnosis. On 17 October, NIHE confirmed that the sample tested positive for the H5N1 avian influenza virus. Following intensive medical management, the patient gradually improved. By 30 October, she had fully recovered and was discharged from the hospital.

Figure 2.4 describes the events that took place during the investigation the avian influenza outbreak. A total of 67 human specimens were sent to the NIHE laboratory for testing. The testing method used was real-time PCR for avian influenza A/H5. Volume of sample was low which was unable to run whole genome sequence. No virus was isolated. Additionally, all contacts tested negative for SAR-CoV-2. Daily health monitoring continued until the 21st day, marking the end of the outbreak.

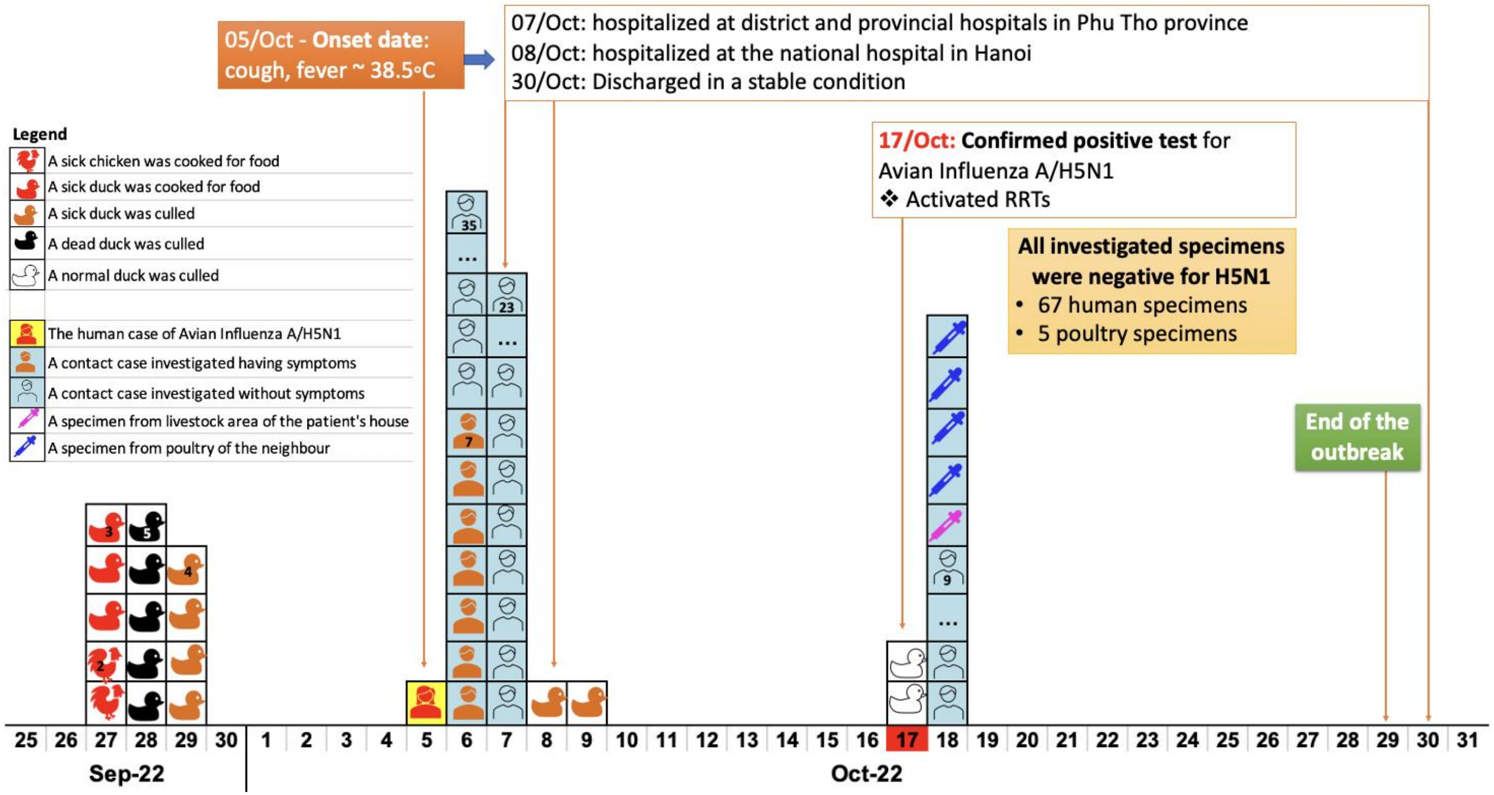

Figure 2.4. Timeline of events: Avian influenza A/H5N1 outbreak investigation and response in October 2022, Phu Tho province

The only confirmed case was represented by the red human icon on a yellow background, which appeared on October 5th. Contact cases were divided into two groups: those with symptoms were indicated by an orange icon on a blue background, while those without symptoms were represented just on a blue background with no-color icon.

The poultry icons depicted two species: chickens and ducks, with various colors denoting their status: Red represents sick animals, black for animals that died and were subsequently culled, orange for animals that were sick and then culled, and white for healthy animals that were culled.The investigation date was highlighted in red and was conducted on October 17th

Close Contacts:

As part of the outbreak investigation to enable early detection of new human cases, identify new outbreaks or links to this outbreak, and assess the potential for human-to-human transmission of avian influenza H5, a comprehensive surveillance effort was conducted, focusing on close contacts of the index case. The results are shown in table 2.2 below:

Table 2.2. *Distribution of the contacts by the level of exposure and health status.*

Close contacts	Level of expsure (cases/%)			Health status (cases/%)	
	Frequent	Not frequent	Contacted in short time	Normal	ill
Family members	7/100%	0	0	7/100%	0
Teachers and schoolmates	32/100%	0	0	25/78%	7/22%
Healthcare workers	0/0%	15/100%	0	15/100%	0
Patients in the same ward	0/0%	4/100%	0	4/100%	0
Neighbours	0/0%	0	7/100%	7/100%	0
Total	39/60%	19/29%	7/11%	58/89%	7/11%

Epidemiology findings of Animal health:

Poultry population in the affected area: On Mar 2022, provincial poultry surveillance reported 02 cases of H5N6 and 04 cases of H5N1 in poultry in Thanh Thuy and Tan Son (different district with the human case), in Phu Tho Province. In Dong Thanh commune, there were 1,050 households engaged in poultry farming, mainly small-scale operations, with only 6 households operating at a farm scale. The total poultry population was 43,000, including 41,000 chickens and 2,000 ducks and geese. In Zone 10, there were 80 households involved in small-scale poultry farming, with a total of 1,430 poultry, including 1,380 chickens and 50 ducks and geese. During the past 16 days since the investigation date (18th October, Figure 2.4), there was no reports of disease outbreaks among the poultry population. There were no reports of natural deaths among poultry, except for the poultry at the patient's household. Vaccination against Avian Influenza has not been administered to small-scale poultry flocks.

Poultry population in the patient's household: The patient's family kept 18 backyard poultry (2 chickens and 16 ducks), of which 2 chickens and 3 ducks got sick and were cooked for food a week before her symptoms appeared, on September 27, 2022 (Figure 2.4). The information on whether the sick birds were properly cooked before consumption could not be independently verified and was based solely on the family's account that they were cooked before being eaten. However, no infection prevention measures (such as masks or gloves) were used when handling and preparing the meat of these sick birds. Over the next two days, 5 ducks died, and 4 sick ducks were culled by the family. More than a week later, an additional 2 ducks got sick and were also culled by the family on October 8 and 9, 2022. There was no poultry left on the investigation day because the remaining 2 ducks, which were thought to be healthy, were culled by the patient's family in the early morning of that day, October 17, 2022.

Poultry samples: Five animal samples were collected, were sent to the animal health laboratory for testing and they were all negative, including one environment sample from the household with H5N1 human case and 04 swab of poultry of neighbor households.

Environmental Findings

During the inspection, one environmental swab from the patient's house and four poultry samples from neighbours were obtained for laboratory testing, and the results of all five samples were negative for avian influenza. The reason for collecting only one environmental sample at the patient's household was because all the poultry were raised in the same area. The carcasses of the uneaten, dead birds had been buried in the backyard after being culled. However, for safety reasons and based on an assessment of sampling sensitivity, a substitute environmental sample was taken from the poultry housing area instead. Therefore, the veterinary staff did not exhume the carcasses for additional testing. The investigation was extended to the surrounding community, the entire patient's residential area, places the patient visited (schools, hospitals), and the poultry farming areas of the patient's family and four surrounding households were thoroughly disinfected using 2% Chloramin B. Implementing biosecurity measures in poultry farms and markets to prevent the spread of the virus.

Other epidemiological response measures include:

- Enhancing surveillance, establishing a particular monitoring system and updating daily reports of suspected cases at all levels within the affected region, maintaining daily disease reporting at all levels until the outbreak is fully contained.
- Strengthening the rapid response teams and the permanent prevention and control units.

- To be prepared with an adequate supply of medicines, materials, chemicals, and equipment for timely handling in the event of new outbreaks.
- Implementing strict quarantine measures and providing timely medical care and treatment to the infected case.
- Disseminating information and educating the public about Avian Influenza prevention and control measures, especially early reporting ILI and sick poultry. Avian Influenza awareness campaigns were broadcasted daily on the radio from October 19, 2022, to October 29, 2022 in the commune.
- Improving communication and coordination between different government agencies and departments involved in Avian Influenza control.

End of the outbreak:

The outbreak was declared to have ended on October 29, 2022, based on the following factors:

- No new human cases had been recorded for 21 days (from the last onset date of the last contact case);
- All high-risk individuals in the area had been tested with negative results for H5N1.
- No sick or dead poultry had been identified or tested positive for Avian Influenza A/H5N1 in the affected area.
- The surrounding environment has been thoroughly disinfected using Chloramin B or other disinfectants.

Discussion

This was an isolated outbreak of Avian Influenza A/H5N1 occurring in Zone 10 of Dong Thanh commune, Thanh Ba district, Phu Tho province; a small rural community. Vietnam has experienced sporadic single-case outbreaks of H5N1 Avian Influenza in humans in the past, and this phenomenon has also been observed in several other countries around the world such as China, the US, the UK and India [9]. These isolated cases underscore the ongoing risk posed by the H5N1 virus to public health and the need for continuous vigilance and preparedness measures.

The outbreak caught the attention of health authorities due to its potential threat to human health, the poultry industry, and the rural population's livelihoods. The outbreak investigation was a crucial and timely response by the Vietnamese health system and the government to an emerging public health threat. The investigation showcased the effectiveness of inter-sectoral coordination, surveillance systems, and rapid response measures in managing and controlling infectious diseases. Currently, there have been no reports of human-to-human transmission or transmission from infected cases to animals.

The healthcare system's ability to promptly recognize and rule out COVID-19 as a potential cause of illness allowed medical practitioners to focus on other possible infectious agents. However, in this case, the delay in laboratory confirmation can be explained by several factors. First, avian influenza A/H5N1 had not been reported in Vietnam for nearly eight years, with the last case detected in Dong Thap province in 2014. As a result, clinicians did not initially suspect it as the primary cause and instead prioritized the management of other critical conditions. Second, confirmatory testing for avian influenza is only available at national reference laboratories such as NIHE, which requires additional time for sample referral and processing. These factors contributed to the delayed confirmation of H5N1 infection and underscore the importance of maintaining awareness and preparedness for emerging and re-emerging pathogens, even when case incidence appears low.

Contact tracing and surveillance efforts were commendable, as they allowed for the identification and monitoring of all potential close contacts of the index case. By monitoring family members, neighbors, schoolmates, teachers, and healthcare workers, authorities were able to detect suspected cases early for treatment and implement isolation and expanded investigation measures if needed. This approach helped prevent further transmission in case there were additional animal reservoirs and contained the outbreak within a limited circle of exposure.

The occurrence of these isolated cases highlights the persistent circulation of the H5N1 virus in poultry populations and the importance of monitoring and controlling the disease at its source. The investigation also revealed the importance of a robust surveillance system for poultry populations. Poultry farming practices, particularly in small-scale household settings, can create opportunities for viral transmission and spillover into humans. Thus, close surveillance of both human and animal cases is essential to detect and respond to potential outbreaks early.The collaboration between public health and animal health departments in tracking and monitoring the poultry population demonstrated the effectiveness of a One Health approach in managing zoonotic diseases.

One unfortunate aspect of this outbreak investigation is that we were unable to collect samples from the suspected poultry at the patient's household. The patient's family had culled the remaining two birds before the field investigation, which prevented us from conducting necessary testing and confirming the presence of the H5N1 virus in the poultry. Collecting samples from the suspected poultry is essential for understanding the source of the infection and assessing the potential risk of further transmission. The destruction of the birds without proper sampling and testing has limited our ability to fully investigate the outbreak and identify any potential links between the human case and the poultry. We must work together to strengthen communication with communities and educate them on the significance of preserving potential evidence during an outbreak investigation. By enhancing public awareness and promoting responsible actions, we can better safeguard public health and prevent the further spread of infectious diseases like Avian Influenza in the future.

The response to the outbreak was also characterized by proactive and immediate control measures. The rapid implementation of disinfection procedures and public health education in the affected community helped contain the outbreak and prevent further spread. Additionally, the communication of information about Avian Influenza symptoms to the community encouraged timely reporting of potential cases and fostered a sense of cooperation between the public and health authorities.

Furthermore, the outbreak investigation highlighted the importance of continued investment in disease surveillance and preparedness. Investing in training provincial health workers in early diagnosis and sample collection for larger-scale outbreaks can further strengthen the country's response capacity.

While the investigation and response were overall successful, there were some challenges and limitations. The lack of a WHO H5 Reference Laboratory in Vietnam might have limited the country's ability to conduct comprehensive genetic analysis of the virus. This emphasizes the need for global cooperation and support in enhancing laboratory capacity in affected countries.

The lessons learned from this investigation can serve as valuable guidance for future outbreak responses and preparedness efforts.

Limitation

We could not collect specimens of the suspected poultry because the remaining animals of the household were culled by the patient's family before the day of investigation. Diagnosis confirming by laboratory for Avian Influenza is not yet available at the provincial level and lower. We also acknowledge that the case was not detected in a timely manner, which may have resulted in missed cases among contacts or other individuals in the community.

Recommendation

After responding to the single H5N1 human case outbreak in Vietnam in 2022, some recommendations can be made to strengthen future preparedness and response efforts.

Enhancing Inter-sectoral Coordination in surveillance system: It is crucial to maintain and strengthen collaboration between different sectors, including agriculture/animal health, human health, and environment. This coordination is vital for routine surveillance, prevention, and the implementation of integrated control measures. By working together, they can mitigate the economic and ecological impacts of the disease, with special attention to its effects on vulnerable rural communities.

Training for Provincial Health Workers: Ensuring that provincial health workers are well-trained in early diagnosis and timely sampling is essential. This will improve the detection and response to larger-scale outbreaks. By identifying cases early on, authorities can prevent the spread of the virus and implement control measures promptly.

Remain Vigilant: As Avian Influenza A/H5N1 is still circulating in poultry flocks, the risk of outbreaks in humans persists. Vigilance is key. Health authorities and relevant agencies must be on high alert and maintain preparedness to respond swiftly to any potential outbreak.

Managing animals: Tightening the management of livestock and poultry farming processes, especially in slaughterhouses, is crucial. Particular attention should be given to ensuring food safety, biosecurity measures, environmental hygiene, and disease prevention protocols. By strictly adhering to these procedures, we can minimize the risk of disease transmission and enhance overall public health and safety.

Community Communication and education: Effective communication with the community is crucial. The public should be informed about Avian Influenza symptoms in humans and animals and what steps to take if they suspect an infection. Raising awareness about preventive measures and the importance of reporting potential cases can help contain the spread of the disease.

By adhering to these recommendations, Vietnam can strengthen its response to Avian Influenza H5N1 and minimize its impact on both animal and human populations.

Conclusion

In conclusion, the outbreak investigation of Avian Influenza H5N1 in humans has provided crucial insights for disease control. The survival of the affected case highlights the importance of timely medical intervention. The lack of evidence for human-to-human transmission, following thorough investigation and analysis of the outbreak, helps to alleviate pandemic concerns. The source of infection through consumption of infected poultry emphasizes the need for public awareness regarding safe food practices. The absence of H5N1 detection in poultry indicates challenges in source identification, necessitating enhanced surveillance. The effectiveness of current SVP surveillance in detecting severe Avian Influenza events emphasizes the significance of proactive monitoring. Overall, these findings underscore the importance of preventive measures, early detection, and a One Health approach in managing Avian Influenza outbreaks.

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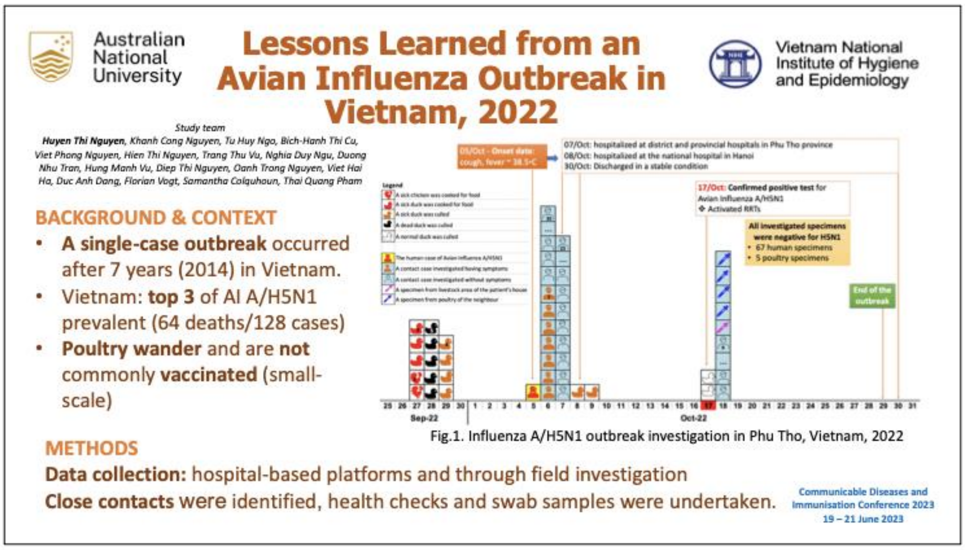
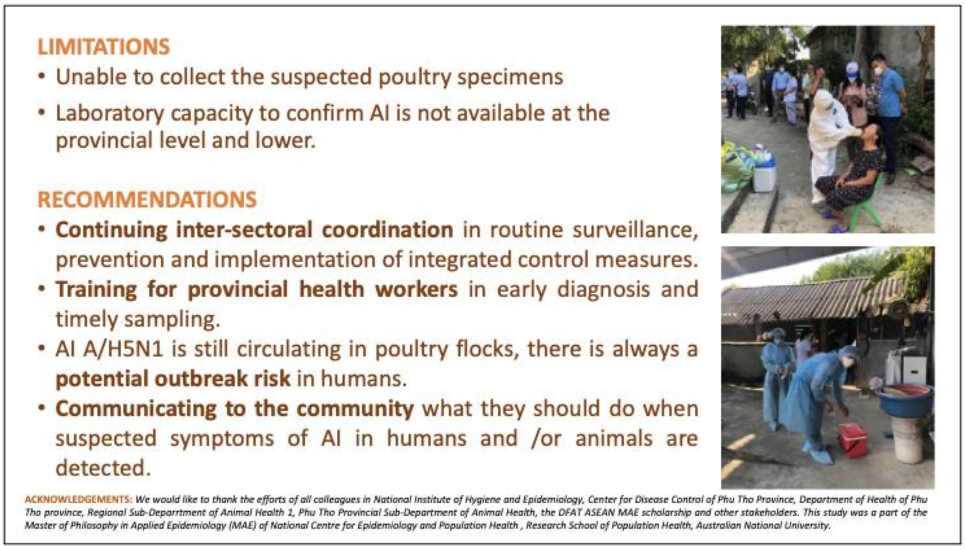
2.8.2 Appendix 2.2. Conference presentation

Conference presentation 1

Presentation at: ***Communicable Diseases and Immunisation Conference 2023 (CDIC2023)**, **19 – 21 June 2023 in Perth, Western Australia.***

- ***Huyen Thi Nguyen**, Khanh Cong Nguyen, Tu Huy Ngo, Bich-Hanh Thi Cu, Viet Phong Nguyen, Hien Thi Nguyen, Trang Thu Vu, Nghia Duy Ngu, Duong Nhu Tran, Hung Manh Vu, Diep Thi Nguyen, Oanh Trong Nguyen, Viet Hai Ha, Duc Anh Dang, Florian Vogt, Samantha Colquhoun, Thai Quang Pham; "**Lessons learned from an Avian Influenza Outbreak in Vietnam, 2022**". Poster oral presentation (6 minutes), **Communicable Diseases and Immunisation Conference 2023 (CDIC2023)**, **19 – 21 June 2023 in Perth, Western Australia.***

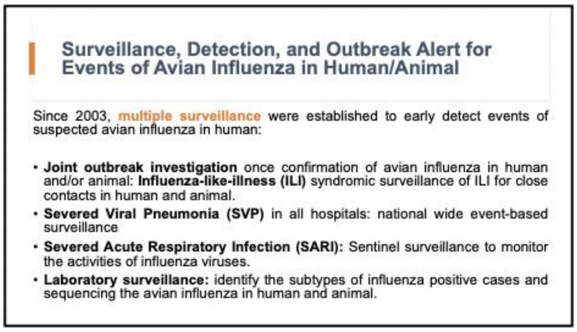


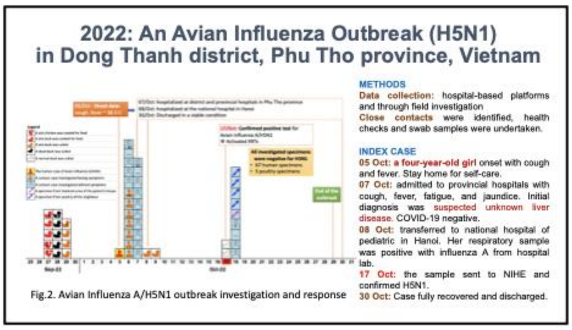


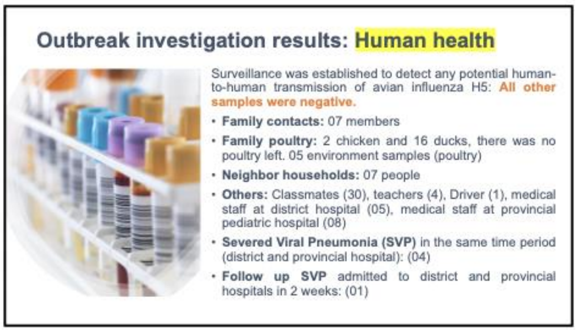
Conference presentation 2

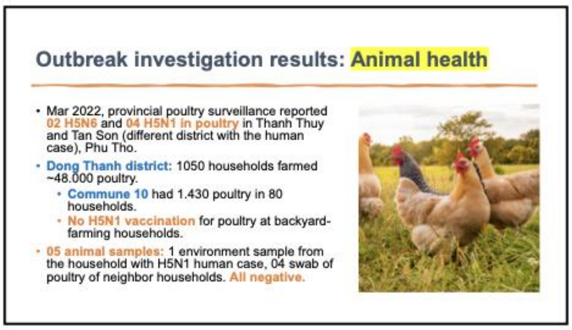
Presentation at ***The 13th International Conference on Public Health among the Greater Mekong Subregion countries 2023 (GMS-13), 01 – 02 July 2023 in Hue, Vietnam.***

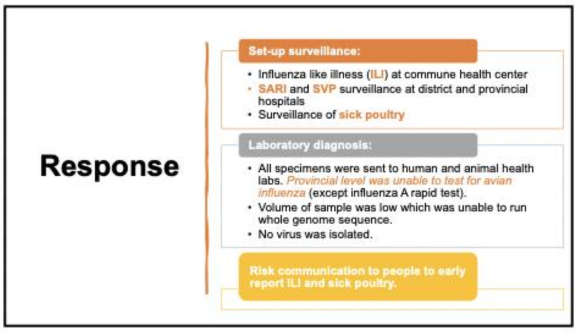
- ***Huyen Thi Nguyen**, Khanh Cong Nguyen, Tu Huy Ngo, Bich-Hanh Thi Cu, Viet Phong Nguyen, Hien Thi Nguyen, Trang Thu Vu, Nghia Duy Ngu, Duong Nhu Tran, Hung Manh Vu, Diep Thi Nguyen, Oanh Trong Nguyen, Viet Hai Ha, Duc Anh Dang, Florian Vogt, Samantha Colquhoun, Thai Quang Pham; "**Lessons learned from an Avian Influenza Outbreak in Vietnam, 2022". Long oral presentation (8 minutes), The 13th International Conference on Public Health among the Greater Mekong Subregion countries 2023 (GMS-13), 01 – 02 July 2023 in Hue, Vietnam.***

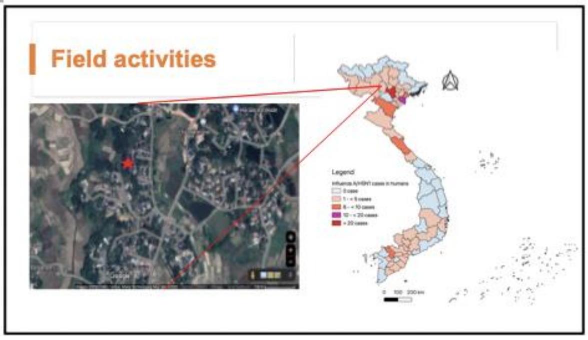




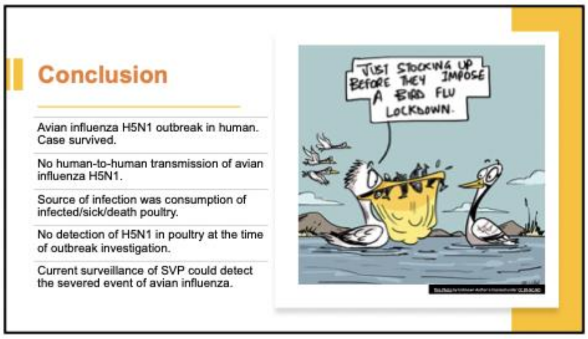







Field activities


Field activities


Conclusion
Avian influenza H5N1 outbreak in human. Case survived.
No human-to-human transmission of avian influenza H5N1.
Source of infection was consumption of infected/sick/death poultry.
No detection of H5N1 in poultry at the time of outbreak investigation.
Current surveillance of SVP could detect the severed event of avian influenza.
JUST STOCKING UP BEFORE THEY IMPOSE A BIRD FLU LOCKDOWN.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Dong Ba district authorities
Trainees of Field Epidemiology Training Program at NIHE.
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2.8.3 Appendix 2.3. Photos of the Investigation in the field

Figure 2.5. Photos of the Investigation in the field, Phu Tho province, Vietnam 2022

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Chapter 3. Analysis an epidemiology dataset

An examination of measles transmission at a pediatric hospital in Vietnam, 2017-2019

List of Abbreviations – Chapter 3

ANU	Australian National University
MAE	Master of Applied Epidemiology Program
NIHE	National Institute of Hygiene and Epidemiology
COVID-19	Coronavirus Disease 2019
WHO	World Health Organization
EPI	Expanded Programme on Immunization
NEPI	National expanded program on Immunization
NCH	National Children's Hospital
ANU HREC	Australian National University Human Research Ethics Committees
QGIS	Quantum Geographic Information System
MCV	Measles vaccine coverage
RSV	Respiratory Syncytial Virus
MeV	The measles virus
HCWs	Healthcare workers
PCR	Polymerase chain reaction
MMR	Measles, Mumps, Rubella
IgG	Immunoglobulin G
IPC	Infection, Prevention and Control

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3.1 Prologue

3.1.1 My role

In my role as the primary investigator for this project, I was responsible for designing the project plan, completing the ethics application, cleaning data from the Excel files of the Vietnam National Children's Hospital (NCH), analyzing and interpreting data using STATA and Quantum Geographic Information System (QGIS) software, conducting the literature review, and authoring the report.

In collaboration with a third party, NHC, I consulted with Dr. Thai, my field supervisor, for advice on collecting and verifying data. I also wrote and distributed the findings to stakeholders.

3.2 Achievements

Throughout my time as a Master of Applied Epidemiology (MAE) scholar, I benefitted from continuous support provided by my academic supervisor and two field supervisors, who played instrumental roles in guiding me towards the project's completion and submission.

I presented my project orally and through a poster at two international conferences in 2023 (these presentations are included in Appendix 3.2). I was honored to receive the First Place Award for Outstanding Poster Presentation at The 13th International Conference on Public Health among the Greater Mekong Subregion Countries 2023 (GMS13) in Hue, Vietnam (pictured below).

3.3 Lessons learned

This project has offered new insights into the dynamics of measles transmission within a hospital setting in Northern Vietnam. Although the data is derived from a major hospital in the northern region, within a unified healthcare management system, I believe that the knowledge gained from this measles model, along with identified gaps in measles response and control within hospital environments and the broader community, can be applied in the southern region when I return to work at the Pasteur Institute in Ho Chi Minh City after completing my MAE studies.

Through the use of software like Stata and QGIS, I acquired valuable data analysis skills. These tools enabled me to handle and analyze large datasets efficiently. I learned to clean, process, and visualize data effectively, which is essential in epidemiological research.

Effective Communication of Sensitive Information: Dealing with sensitive information, such as the transmission of a contagious disease within a hospital, taught me the importance of clear and responsible communication. I learned to convey findings in a way that is consise, clear and informative without causing unnecessary panic. This involved working closely with healthcare authorities and stakeholders to ensure the appropriate dissemination of information.

Interdisciplinary Collaboration: The project emphasized the value of interdisciplinary collaboration. Working closely with healthcare professionals, data scientists, and public health experts allowed for a holistic approach to understanding and mitigating the outbreak. It taught me the importance of effective teamwork and the exchange of knowledge across different domains.

Through this project, I have come to realize that secondary data sources, such as data from surveillance systems or routine hospital practices, are valuable resources with significant untapped potential in Vietnam. The use of these data deserves further analysis to transform raw data into meaningful information, shared among multiple parties to obtain evidence-based information for improving healthcare and health protection with a more scientific approach.

Conducting a literature review on measles outbreaks in hospitals taught me the importance of thorough research. It emphasized the need for up-to-date information and the significance of evidence-based practices in preventing and managing infectious diseases. This process underscored the ever-evolving nature of epidemiology and the necessity of continuous learning.

3.4 Public health impact

Measles remains a prevalent and ongoing concern in Vietnam, affecting the community and impacting healthcare settings. The findings from this analysis will contribute to raising awareness and enhancing strategies to address the deficiencies in measles control. This proactive approach helps reduce the risks of both individual and community health.

Understanding the predominant pediatric hospitalization model, which often involves young children with multiple complications and potential co-infections, highlights the challenges of clinical healthcare. It underscores the importance of early diagnosis, timely isolation, strong Infection, Prevention and Control (IPC) systems and timely treatment.

Moreover, the extremely low vaccination rates among children with underlying health conditions provide critical data for evaluating vaccination programs. This work emphasizes the need for targeted vaccination campaigns for vulnerable groups, including those with compromised immune systems or nutritional deficiencies. Administering vaccinations under hospital supervision may be a viable approach for these groups.

The information on maternal antibodies in infants under nine months of age further underscores the reasons behind the high incidence of measles in this particular group. It highlights the necessity of research on maternal antibody transmission to better understand and address the measles vulnerability in this ineligible population.

Overall, these insights from the analysis contribute to a more informed and proactive public health response to measles, encompassing preventive measures, vaccination strategies, and specialized care for at-risk populations.

3.5 Ackowledgements

I would like to acknowledge and thank the following the institutions, organisations and individuals for their invaluable support and contributions throughout my research project:

- *Vietnam National Institute of Hygiene and Epidemiology (NIHE) and Vietnam National Children Hospital (NCH):* Your data, support, insights, collaboration and resources were essential and shaped this project's success.

- *Supervisory Team:* Associate Professor Samantha Colquhoun, Associate Professor Pham Quang Thai, Dr. Florian Vogt, and Dr. Nguyen Cong Khanh, your guidance and expertise were indispensable in this endeavor.

3.6 Master of Philosophy in Applied Epidemiology core requirements

✓ Literature review (Appendix 3.1)

✓ Analyse a public health dataset

✓ Prepare an abstract and oral presentation of the project at a national or international scientific conference (Appendix 3.2)

3.7 Abstract

Background

In the period 2013 to 2018, Vietnam was one of the five countries with the highest measles incidence in the Western Pacific region. Multiple cases of measles were identified in the National Children's Hospital in Hanoi, Vietnam, between 2017 and 2019. Measles vaccine coverage (MCV2) in the north of Vietnam was reported to be above 90% during this period. We investigated the source of acquisition of measles infection in pediatric patients hospitalised during the period and examined transmission risk factors within the hospital environment.

Methods

We undertook a retrospective study of hospitalized patients between, who had a diagnosis of measles between 2017-2019. Medical records and hospital data systems were searched for notification of laboratory-confirmed measles cases in patients admitted to the hospital and were assessed as community- or hospital-acquired cases based on case definitions developed for this study. Of the hospital-acquired cases, data were also reviewed for possible risk factors contributing to acquisition in this location.

Results

Of 2056 laboratory confirmed measles cases identified in the Vietnam National Children's Hospital during 2017-2019, 7.2% (n=148) were confirmed as hospital-acquired cases. A further 30.8% (n=633) were suspected hospital-acquired cases, the remainder were community-acquired cases. Nearly 90% of cases were aged less than five years, and 46% of all cases identified were aged less than nine months. Only 9.1% of eligible patients older than nine months had received at least one dose of measles containing vaccine. Coinfection was identified as a risk factor for hospital acquisition in 8.6% of patients, especially in unvaccinated

patients; Adenovirus ($p<0.001$), RSV ($P<0.001$) and pertussis ($p=0.007$). Data on nutritional status was not available.

Conclusion

This study shows evidence of pediatric measles transmission in a hospital setting, especially among unvaccinated patients. Further investigation is required to identify risks of mealses transmission within the hospital and areas of low immunization coverage in the community.

Keywords:

Measles, infection transmission, hospital, immunization, vaccine coverage, Vietnam

3.8 Introduction

3.8.1 Epidemiology of measles

Measles is an highly contagious and severe infectious disease with a high rate of morbidity and mortality, especially among undernourished or immunocompromised children. It is caused by the measles virus (MeV) in the Morbillivirus genus of the Paramyxoviridae family. The incubation period for measles is usually 10 to 14 days (with a range of 7 to 23 days) from exposure to the onset of symptoms. Initial symptoms generally include fever, fatigue, cough, conjunctivitis, and a coryza. The distinctive maculopapular rash typically emerges two to four days after the prodromal phase starts. Patients are typically contagious from about four days before the rash appears until four days after it becomes visible [1-3]. Measles can lead to many serious complications such as pneumonia, otitis media, diarrhea, and in severe cases, encephalitis or death, especially in malnourished or immunocompromised children. Pneumonia is the leading cause of measles-related deaths in children. In addition, measles can temporarily suppress the immune system, making children more susceptible to other infections [4]. Measles virions can remain infectious for a few hours when suspended in the air. It mainly spreads from person to person through respiratory droplets in the air, which disperse quickly. Contagion can even happen after the infected person has left the room, up to two hours before the arrival of susceptible individuals [5]. Measles has been shown to induce immune amnesia, which temporarily impairs the body's immune defenses and increases vulnerability to secondary respiratory infections, including RSV, adenovirus, and pertussis [6, 7]. In clinical environments, hospital-acquired transmission of measles may occur, making disease management more complex—particularly when patients contract measles while being hospitalized for unrelated health conditions [8]. In specific contexts such as refugee camps or low-income countries, where there is limited herd immunity, high birth rates, and crowded living conditions, measles transmission is more prevalent among infants and preschool children. As vaccination coverage improves, the typical age of measles infection can shift to adolescents and young adults. These older groups remain vulnerable because they were not vaccinated or exposed to the wild-type measles virus due to decreased transmission among younger vaccinated groups [9]. Measles presents as a seasonal disease in endemic areas. In temperate regions like northern Vietnam, the incidence peaks during late winter and early spring. In the pre-vaccination era, measles epidemics occurred approximately every 2 to 3 years, resulting in an estimated 30 million cases of measles and over 2 million deaths worldwide each year by the age of 15. Since the Expanded Programme on Immunization (EPI) in 1974 by the World Health Organization (WHO), the global incidence of measles has significantly decreased [10, 11]. In 2000, in pursuit of the goal of eradicating measles globally, the WHO prioritized vaccination campaigns in 45 countries that accounted for over 90% of the estimated global measles-related deaths [12, 13]. The WHO's strategy for reducing measles is based on achieving vaccine coverage of over 90% for two doses of the vaccine, administered at 9 and 18 months of age [14].

In the period from 2013 to 2018, Vietnam was one of the five countries with the highest number of measles cases in the Western Pacific region [2]. Northern Vietnam has experienced cyclical surges in measles cases approximately every 4–5 years, with notable outbreaks in 2009, 2014, and again in 2018–2019. A comprehensive investigation of the 2013–2014 measles outbreak in northern Vietnam revealed 9,577 confirmed cases, with an incidence rate of 116.4 per million. Importantly, over 55% of patients were children under five years old, and approximately 76% were unvaccinated or had an unknown vaccination history. The outbreak originated in minority populations in mountainous areas before spreading to denser urban centers [15]. The northern region, particularly the Red River Delta area, is densely populated with high rates of internal migration, posing challenges for routine immunization tracking and coverage. The National Children's Hospital (NCH) in Hanoi is the largest pediatric referral hospital in Vietnam and plays a central role in the diagnosis, treatment, and prevention of pediatric infectious diseases, including measles. As a tertiary hospital, NCH receives severe and complicated cases from across the country, especially during outbreaks. During measles outbreaks, NCH has implemented strict infection prevention and control (IPC) measures. These include isolating measles patients in designated units, assigning dedicated staff and equipment, enforcing the use of personal protective equipment (PPE), and requiring vaccination for all healthcare workers. Special care areas are also arranged for high-risk children with chronic diseases to minimize exposure. Family visits are limited to reduce transmission. In addition to patient care, NCH contributes to national surveillance, outbreak response, and health policy through data sharing and technical guidance.

There were some Vietnamese studies assessing recent outbreaks of measles for epidemiological, clinical and genome characteristics on the community scale but there has been no studies of hospital-associated measles. The incidence was highest in those <1 year old, decreasing with greater age. Most of the measles cases had no Measles Containing Vaccine (MCV) immunisation or were ineligible for vaccination with MCVs under the NEPI [15]. This proposed study would increase our understanding of the epidemiological and clinical characteristics among cases in healthcare settings, as well as their transmission patterns. This will contribute to a better overall understanding of measles throughout different conditions and may assist in guiding policy, service provision, prevention strategies and other public health interventions.

3.8.2 Measles outbreak in hospital environment: a literature review

Introduction:

The occurrence of a measles outbreak within a hospital or healthcare facility is a multifaceted concern that transcends mere epidemiological interest. Hospitals are home to an intricate web of interconnected individuals: patients seeking treatment, healthcare workers administering care, visitors offering support, and countless others. This interplay of individuals creates a milieu ripe for the transmission of contagious diseases, especially one as virulent as measles. It not only threatens the health of the vulnerable individuals who seek care within these locations but also casts a spotlight on the broader issues surrounding infection control, immunization coverage, healthcare worker responsibilities, and the very essence of patient safety.

With an astonishing basic reproduction number (R0) ranging from 12 to 18, known to be among the highest in infectious diseases and highly variable depending on different contexts, a single case of measles has the potential to ignite an outbreak if the conditions are ripe for transmission [16]. This underscores the urgent need to comprehensively grasp measles outbreaks within a hospital setting.

This literature review delved into this topic, recognizing that measles outbreaks in hospitals are not isolated incidents but rather a reflection of broader issues. We explored the epidemiology of measles within hospital settings, the factors that contributed to the ignition and propagation of these outbreaks, such as vaccination rates, healthcare worker immunity, and patient demographic patterns. We also closely examined the strategies and preventive measures that hospitals employed to mitigate the risk of measles transmission.

Method

I conducted a brief literature search using PubMed search platform with the selection criteria as follows:

Inclusion Criteria:

- Peer-reviewed journal articles and published non-peer-reviewed reports
- Measles outbreak in a hospital environment as the subject
- Published between 2013 and 2023
- Published in the English language
- Study subjects humans

Exclusion Criteria:

- Unfinished reports or publications
- Letters, editorials, comments, interview and clinical trials
- Reports not addressing measles events/outbreaks in hospitals
- Publications not in English

Search strategy

I searched references in the PubMed database using various combinations of the following search terms “Measles”, “outbreak”, “transmission”, “hospital”, “hospital acquired”, “healthcare“, “nosocomial” filters applied: “MeSH Terms”.

Summarise the findings:

There were a total of 374 studies initially searched (211 from the first search and 163 from the second search on PubMed). I narrowed down the articles using exclusion criteria (Figure 3.1), resulting in a final screening of 15 relevant articles, which were. Summarized individually in Appendix 3.1.

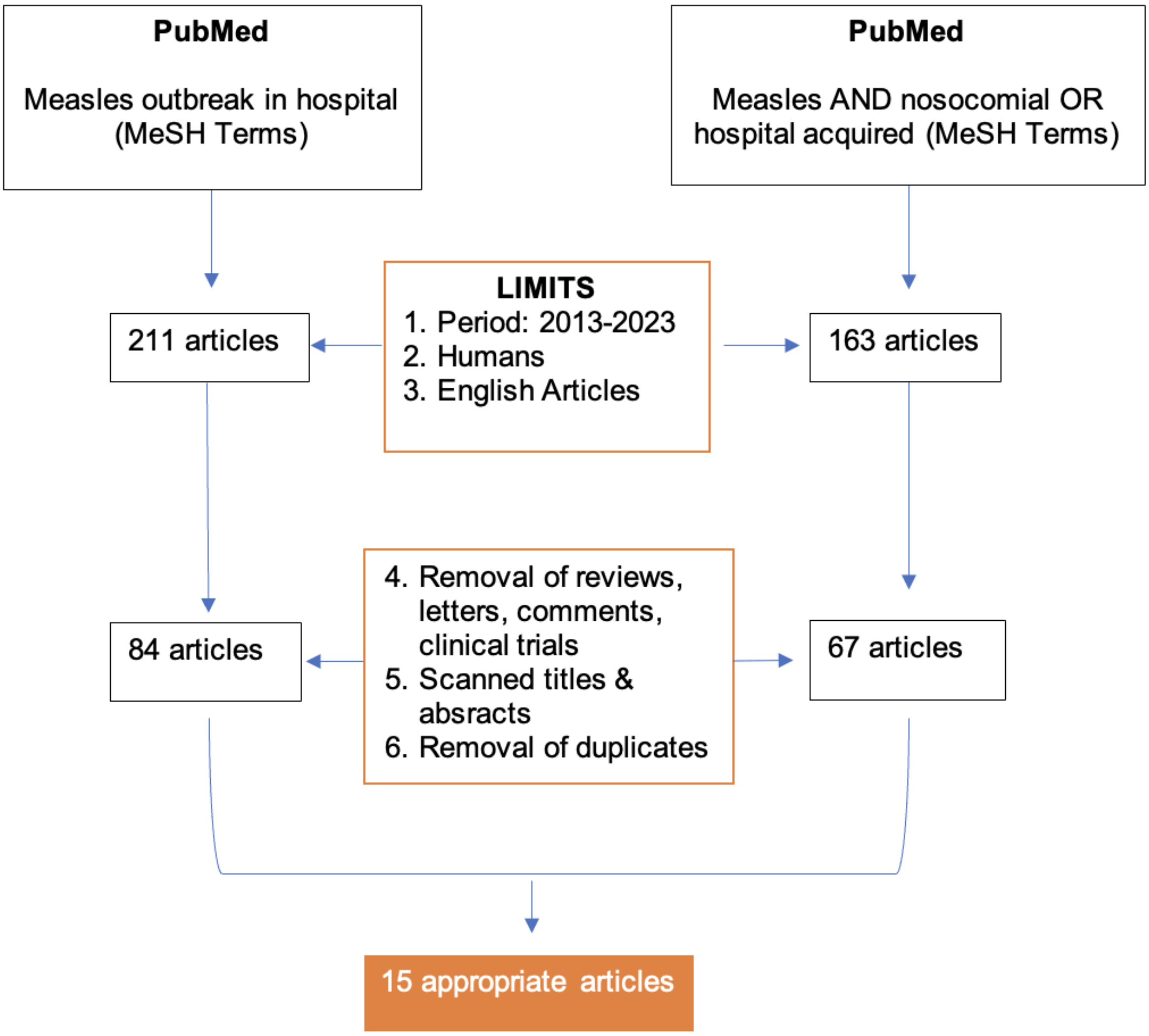

Figure 3.1. Flowchart presenting the search criteria, review process, and the final count of documents, grouped by search level

All of these studies reported measles cases with nosocomial outbreaks or links to hospitals. There were two studies published in 2023, one study each in 2022 and 2021, four studies in 2020, two articles for each year in 2019 and 2018, and one study for each year in 2017, 2015, and 2013. The countries included were Spain, Korea, Ireland, USA, England, Austria, Belgium, China, Singapore, Portugal, Italy, and France.

In the context of nosocomial measles outbreaks, there are common trends in the epidemiological data. Typically, affected individuals encompass a wide age range, with a substantial portion of adults [17-23]. A significant proportion of patients were unvaccinated (average higher than 60%) [17, 20, 22, 24-26], including infants who were not yet eligible for vaccination [17, 23-25]. Some countries with high vaccination coverage or measles elimination status, such as Spain, Korea, and England, still experienced measles outbreaks due to imported cases [17-19, 24]. These outbreaks involved various groups, including mostly healthcare workers (HCWs), inpatients, and caregiver [27]. Common locations for infection transmission included waiting rooms, emergency departments, and pediatric wards within healthcare facilities [17, 20, 27, 28]. Complications such as pneumonia and hepatic disorders arose in a substantial proportion of cases underscoring the disease's severity [26, 29]. Additionally, a noteworthy percentage of patients presented with atypical symptoms from 20% [17, 28, 29], making timely diagnosis challenging. Several risk factors contributed to the sustainability of these outbreaks, such as a lack of isolation space [22, 28], delayed diagnosis of the initial case [27], and early transmission within the emergency department [17, 28].

A combination of strategies and preventive measures were employed to manage nosocomial measles outbreaks. This included isolating infected individuals to prevent further spread, conducting thorough contact tracing to identify and assess susceptible contacts, and offering vaccination to healthcare workers, patients, and exposed contacts. In some cases, unvaccinated healthcare workers were excluded from work. Enhanced health surveillance of healthcare workers and patients was implemented to rapidly detect symptoms, while raising awareness about measles within healthcare networks and the public through various means, such as reports, press releases, and media communications. These studies highlighted the significance of comprehensive training programs, vaccination policies, and awareness campaigns to prevent nosocomial measles transmission and boost vaccination coverage. Seroprevalence surveys were also conducted to assess population immunity, revealing the need for improved vaccination coverage in certain areas.

Discussion:

The emergence of nosocomial measles outbreaks, whether transmitted by patients or healthcare staff, poses a significant threat, particularly to vulnerable and debilitated patients. These outbreaks are associated with increased mortality and morbidity rates due to the heightened risk they present. Vulnerable individuals, such as those with compromised immune systems, are more susceptible to severe complications from measles, making it imperative to address and mitigate these nosocomial outbreaks.

Vaccination emerges as the most reliable and effective tool in preventing the nosocomial spread of measles. It is the first line of defense against this highly contagious virus. Occupational medicine plays a pivotal role in this regard, as it is responsible for identifying and ensuring the vaccination status of healthcare workers (HCWs). HCWs serve as potential sources of infection within healthcare settings. Detecting unvaccinated or under-vaccinated

HCWs is crucial to prevent the transmission of the virus within the hospital environment. Hospitals must prioritize and implement strict vaccination policies, ensuring that HCWs are adequately protected to minimize the risk of nosocomial transmission.

The resurgence of measles, even in countries with high vaccination coverage, as evidenced by imported cases, highlights the ever-present risk of the virus re-establishing itself. Vigilant surveillance, early detection, and robust vaccination campaigns are essential to keep measles at bay and avoid its resurgence. Preventing nosocomial transmission remains a top priority for healthcare institutions, not only to safeguard the health of patients but also to protect the healthcare workforce itself.

Conclusion:

In conclusion, nosocomial measles outbreaks are a significant concern, particularly for vulnerable patients in healthcare settings. Vaccination stands as the most reliable means of preventing the nosocomial spread of measles, with healthcare workers playing a central role in this effort. Maintaining rigorous vaccination policies, heightened surveillance, and comprehensive awareness campaigns are essential to thwart potential outbreaks and prevent the resurgence of this highly contagious and potentially deadly disease. By doing so, we can ensure the safety of both patients and healthcare workers while mitigating the risk of measles transmission within healthcare facilities.

3.9 Methods

3.9.1 Objectives

The project seeks to improve our understanding of the epidemiolocal, clinical characteristics and transmission patterns of measles in the hospital environment in Hanoi, Vietnam.

1. To use records of laboratory-confirmed measles admitted at NCH from 2017 to 2019 to discribe the distribution of measles by age-group, sex and geographic region.

2. To compare the clinical, epidemiological features and complication between community-acquired measles and those co-infected with another agents (hospital acquired cases) (initially hospitalized for another cause/ with underlying medical conditions).

3.9.2 Study type

A retrospective study was conducted on measles cases identified in the National Children Hospital (NCH) in Hanoi, Vietnam between 2017 and 2019.

3.9.3 Study subject and Case definition

Data were sourced from the NCH databases. In our study, all subjects were diagnosed as laboratory positive for measles by PCR or IgM, and we defined the "Date of onset" as the same as the "Date of rash".

The case definitions were first developed by the reaseach team. We categorized the study subjects into three groups based on specific timelines and criteria, in accordance with the following:

Basis for Timelines [30]:

- Incubation period of Measles: This is defined as 7-21 days.
- Measles transmission period: It covers the 4 days before and after the date of onset, signifying the period during which measles can be transmitted.

Measles Exposure in Hospital [4]:

- Shared the same room with a confirmed measles case during the transmission period for 15 minutes or more.
- Stayed at least 15 minutes in the affected ward, where a confirmed measles patient was present, and left within 2 hours.
- Had direct contact with a confirmed case, involving skin-to-skin or skin-mucous contact.

Three groups with case definitions:

- *Community-acquired cases:* These individuals were diagnosed with measles while hospitalized, developed symptoms within 7 days of admission, and had no known exposure to the measles virus within the hospital during their stay.
- *Suspected hospital-acquired cases:* These subjects were initially hospitalized for a different illness but later received a confirmed measles diagnosis. They developed

measles symptoms either between the 8th and 21st day of their hospital stay or within 21 days of being discharged from the hospital or having exposure in any health facility.

- *Hospital-acquired cases:* This group included individuals who were initially hospitalized for another condition but later received a confirmed measles diagnosis. They developed measles symptoms either on the 22nd day of their hospital stay, within 7 days of being discharged from a healthcare facility where prior treatment lasted for more than 14 days, or as a suspected hospital-acquired case with known exposure within the hospital.

3.9.4 Data collection, data cleaning and data analysis

- All laboratory-confirmed measles cases admitted to the National Children's Hospital (NCH) from 2017 to 2019 were included. Outpatients and ED cases or short-stay patients without a measles diagnosis were not included in the dataset. However, ED and short-stay patients with a confirmed measles diagnosis were captured and included in the study. The data extracted from electronic medical records and paper records comprised demographic information (age, sex, residence), clinical data (symptom onset date, admission date, complications, co-infections, underlying conditions, discharge status), and laboratory test results (IgM and PCR). Vaccination status was obtained through vaccination records (paper or electronic) or, if unavailable, via parent or caregiver interviews.

- Data from electronic medical records and paper records were entred into Epidata software then extracted to an Excel file. Data were cleaned and imported into Stata/SE 17 & QGIS software for analysis. Variable ranges were checked to assess data entry errors and ensure that data were from the correct study period. Cases with missing information for key variables (e.g., date of rash onset) were excluded from the relevant analyses. Duplicate notifications and test results (multiple tests on the same date) were assessed and dropped.

- String variables were re-coded, and new aggregated variables were created. New variables included:

    1. Age-groups from Date of Birth

2. Geographical region from District/Province: Locations were classified according to the geographic features of the Northern region, into delta, mountainous, and midland regions, as illustrated on Figure 3.2 as follows:

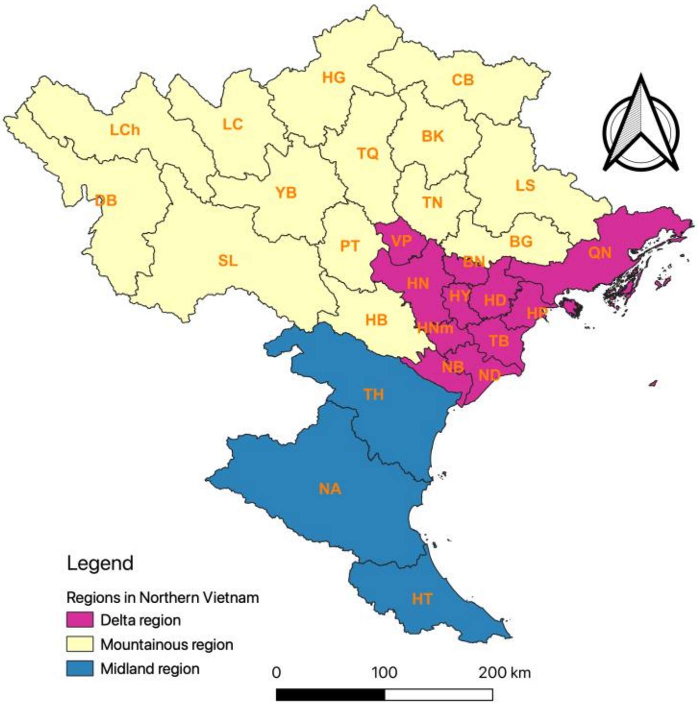

Figure 3.2. Map of regions in Northern Vietnam

3. Case classification was determined based on two key factors: the duration between symptom onset, hospital admission and test result dates, and the exposure factors collected during the investigation.

- A unique ID number (not linked to medical record ID or lab number) was generated for each individual.

- Missing data for key variables (e.g. date of rash onset) were excluded from analysis.

- Data were analyzed using Stata/SE 17 & QGIS software. Descriptive statistics summarized demographics, clinical features, complications, and vaccination status. Categorical variables were reported as frequencies and percentages; continuous variables as means or medians. Respiratory diseases such as RSV, pertussis, and adenovirus were included because they are common co-infections reported in measles patients and contribute significantly to morbidity, especially in hospitalized children. These diagnoses were identified through available laboratory confirmation and/or ICD coding in the hospital records. Crude odds ratios (ORs) with 95% confidence intervals were calculated to explore associations between key variables. Due to data limitations, adjusted analyses were not performed. A p-value < 0.05 was considered statistically significant.

3.10 Ethics approval

Ethics approval from Vietnam National Children's Hospital's Research Ethics Committee under the Decision no. 473/BVNTW-HĐĐĐ, dated 17/03/2022 (IRB – VN 01037/IRB00011976/FWA00028418) and Ethics approval from ANU HREC under protocol 2022/473.

3.11 Results

3.11.1 Epidemiological characteristics of measles cases admitted at NCH 2017-2019

Table 3.1 shows that there were a total of 2,056 pediatric cases indentified under 18 years old treated at the NCH over a 3-year period and diagnosed as measles-positive during their treatment, 62.4% were male. Of these, over 7% were confirmed as hospital-acquired cases, with a further 30% being suspected hospital-acquired cases, and the remainder were community-acquired.

There were 10 fatalities, with 70% of them linked to cases initially admitted for illnesses other than measles. The proportion of deaths by case definition was 0.2% (3/1.275) among community-acquired cases, 0.7% (1/148) among hospital-acquired cases, and 0.9% (6/633) among suspected hospital-acquired cases, with an overall mortality of 0.5%. All mortality proportions were below 1%. Given the low number of deaths, no further stratified analysis was performed. Nearly 90% of cases were under 5 years of age, and almost 46% of them were under 9 months, making them ineligible for the first dose of measles vaccination in Vietnam. Furthermore, 62.4% of these cases were male. 70.8% of cases were located in the Delta region. However, the rate of hospital-acquired measles cases in this region was the lowest compared to the Midland and Mountainous regions, with respective rates of 6.3%, 8.6%, and 10.1%.

Table 3.1. General information of measles cases

	Community-acquired	Hospital acquired	Suspected hospital acquired	Total
Total cases	1.275 (62%)	148 (7,2%)	633 (30,8%)	2.056 (100%)
Death	3	1	6	10
Age groups				
<6 m	211 (54,5%)	37 (9,6%)	139 (36%)	387 (100%)
6-8 m	334 (60,5%)	47 (8,5%)	171 (31%)	552 (100%)
9-11 m	257 (60%)	32 (7,5%)	139 (32,5%)	428 (100%)
1-4 y	301 (63,8%)	22 (4,7%)	149 (31,6%)	472 (100%)
5-17 y	172 (79,3%)	10 (4,6%)	35 (16,1%)	217 (100%)
Sex				
Male	781 (60,9%)	95 (7,4%)	407 (31,7%)	1283 (100%)
Female	494 (63,9%)	53 (6,9%)	226 (29,2%)	773 (100%)
Location				
Delta	939 (64.5%)	92 (6.3%)	424 (29.2%)	1455 (100%)
Midland	167 (53.2%)	27 (8.6%)	120 (38.2%)	314 (100%)
Mountainous	169 (58.9%)	29 (10.1%)	89 (31%)	287 (100%)

Examining the distribution of measles cases admitted to NCH over time, Figure 3.3, indicates that hospitalizations for measles cases began to gradually increase in mid-2017 and reached their peak in 2019, with 1,301 cases, constituting 63.3% of the total. In general, cases were most frequently recorded from February to June, with a notable surge in 2019. Notably, the proportion of hospital-acquired cases relative to the total cases was highest in 2017, accounting for 21 out of 128 cases, or 12%. This proportion then decreased significantly in 2019 and 2018 to 7% and 6%, respectively. Similarly, the annual percentage of suspected hospital-acquired cases was also highest in 2017 at 35%, gradually declining to 32% in 2018 and 30% in 2019.

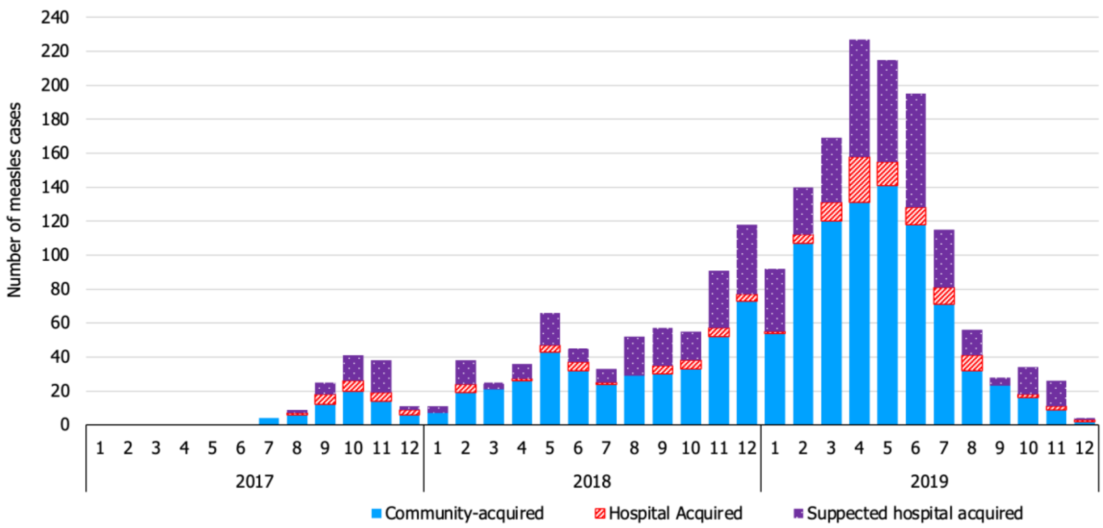

Figure 3.3. Laboratory confirmed measles cases at NCH in Hanoi, by month of year, 2017-2019

The map on Figure 3.4 illustrates the distribution of community-acquired measles cases hospitalized at NCH in Hanoi from 2017 to 2019 (n = 1,275 or 62% of total cases). In this map, we have excluded cases with diagnosis of hospital-acquired or suspected hospital acquired measles, as the NCH is located in Hanoi.

In terms of the geographical location of community-acquired cases, the majority were concentrated in the Red River delta and midland areas. Notably, Hanoi (HN) had more than 500 hospitalizations, followed by Nghe An (NA) with nearly 100 cases, and Hung Yen (HY) with 80 cases.

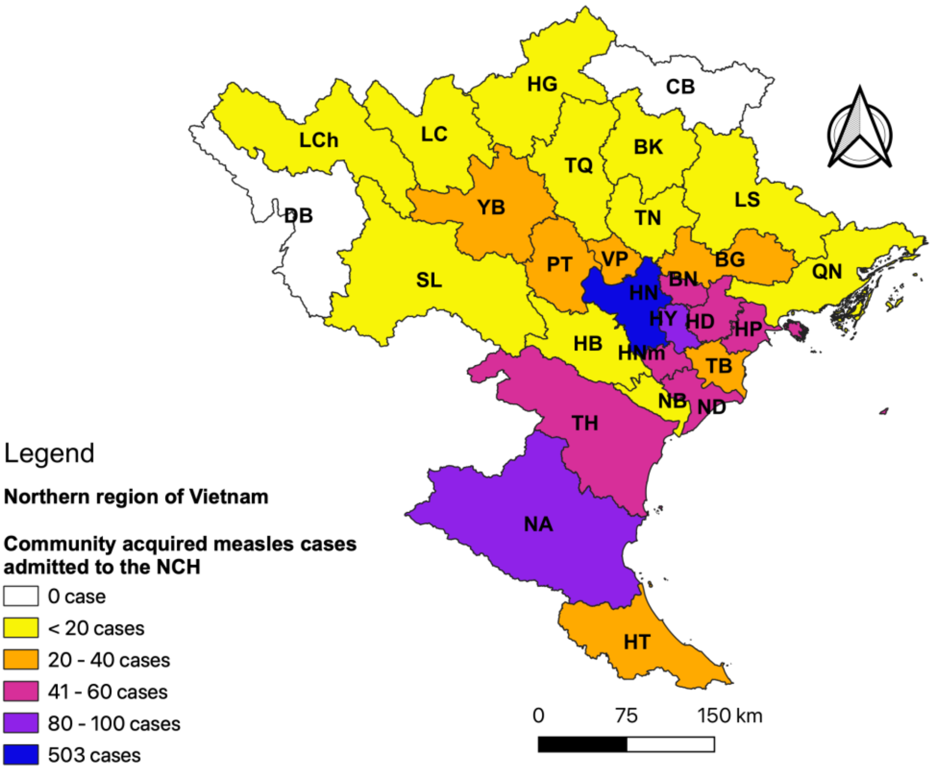

Figure 3.4. Distribution of community-acquired measles cases hospitalized at NCH in Hanoi by location, 2017 to 2019 (n = 1.275 (62%).

Figure 3.5 highlights a common status across all three groups, which is the widespread lack of vaccinationOverall, only 9.1% of eligible patients older than 9 months had received at least one dose of MCV.

Looking at each group individually, the percentage of pediatric patients who received at least one dose of MCV decreased in the order of community-acquired cases (12%), suspected hospital-acquired cases (5%), and hospital-acquired cases (2%).

For the hospital-acquired cases, 98% of pediatric patients had not received any MCV doses, comprising 84 patients under 9 months of age (56.8%) and 61 children old enough to have received at least one dose of MCV but had not, accounting for 41.2%.

In the other two groups, the percentage of eligible children who had not received any MCV doses was also high, at 43% for community-acquired cases and 45% for suspected hospital-acquired cases.

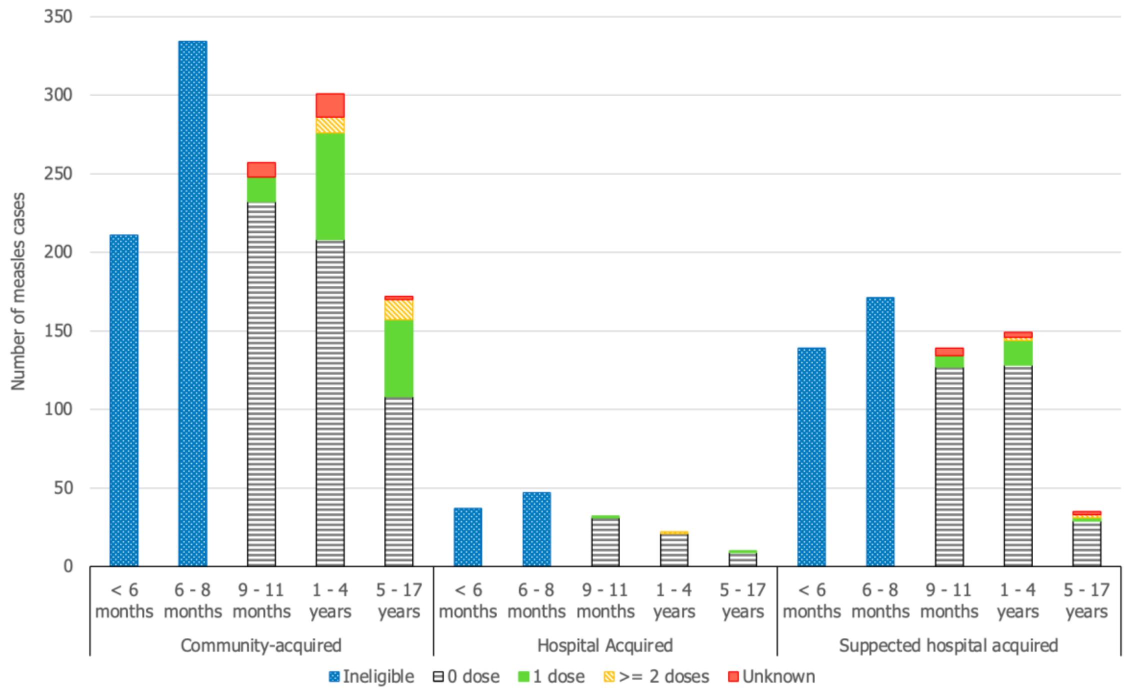

Figure 3.5. Age distribution and vaccination status of measles cases in NCH, 2017-2019

3.11.2 Clinical characteristics of measles cases admitted at NCH 2017-2019

Bronchitis and pneumonia were the most common complications in all three sources of infection. Astonishingly, pneumonia was recorded in 90% of the deaths and and was also the most frequently reported complication within the hospital-acquired group, affecting 31.8% of those cases (Figure 3.6)

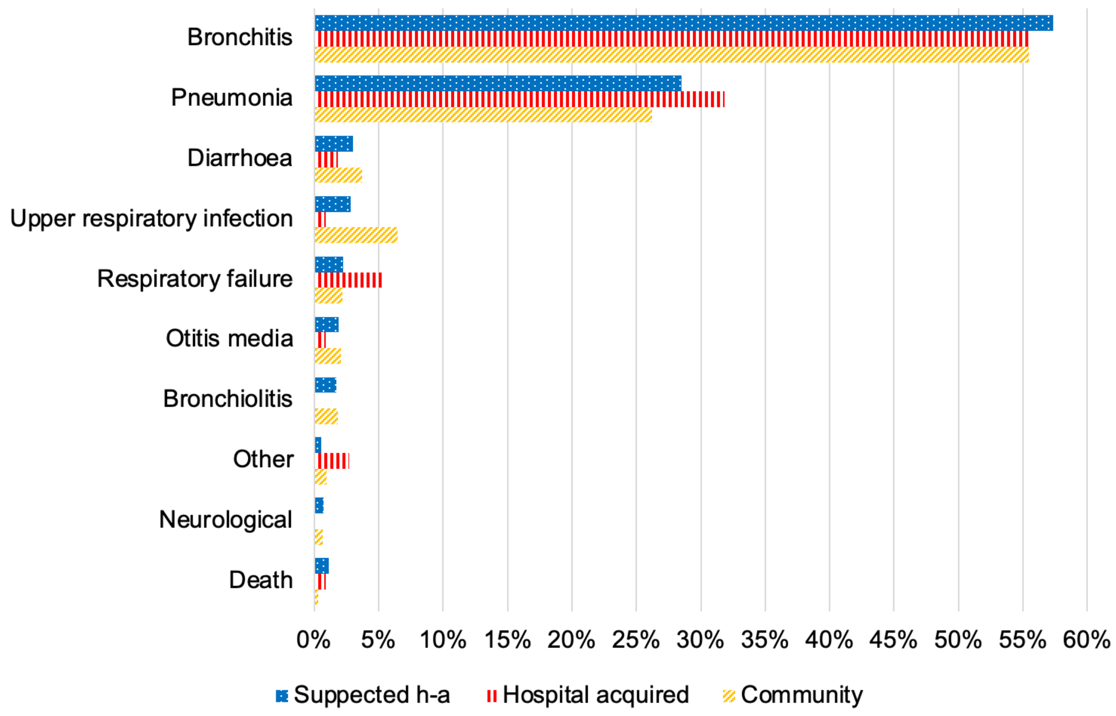

Figure 3.6. Complication rate by sources of infection at NCH, Hanoi, Vietnam, 2017-2019

In examining the relationship between the source of infection and co-infection with other pathogens, our findings revealed that RSV, adenovirus, and pertussis showed statistically significant associations for the hospital-acquired cases (Table 3.2). As a result, co-infection was identified as a risk factor for hospital acquisition in 8.6% of patients, particularly in cases of unvaccinated patients.

Table 3.2. *Comparision among sources of infection at NCH, Hanoi, Vietnam, 2017-2019*

Coinfection with	Sources (cases)	OR	P>chi2	(95% Conf. Interval)
	Community acquisition (9)	1.00	.	.

Coinfection with	Sources (cases)	OR	P>chi2	(95% Conf. Interval)
RSV	Suspected hospital acquisition (13)	2.95	0.0094	1.25 - 6.95
	Hospital acquisition (9)	9.11	0.0000	3.52 – 23.57
Adeno	Community acquisition (37)	1.00	.	.
	Suspected hospital acquisition (41)	2.32	0.0002	1.47 – 3.66
	Hospital acquisition (16)	4.06	0.0000	2.18 – 7.53
Pertussis	Community acquisition (7)	1.00	.	.
	Suspected hospital acquisition (7)	2.03	0.1798	0.71 – 5.80
	Hospital acquisition (5)	6.33	0.0026	1.97 – 20.33

3.12 Discussion

Measles remains a circulating and concerning infectious disease in Vietnam. Statistics from the national infectious disease surveillance system indicate that despite consistently achieving high vaccination coverage of over 90% for the first measles vaccine dose at the provincial level over the past two decades [31, 32], every four years, there is a resurgence in the number of measles cases. The most recent nationwide measles epidemic occurred in 2018-2019 [33, 34].

When the number of measles cases in the community rises, there is an increased demand for medical facilities to provide treatment and care, particularly for severe cases that may necessitate referral to higher-level healthcare institutions. In northern Vietnam, the NCH plays a central role as the primary facility for managing severe cases, making it the preferred choice for such medical care. During the outbreak period, this hospital was estimated to provide treatment for approximately 30-40% of all cases in the 28 northern provinces of Vietnam.

The peak period of hospitalizations predominantly falls between February and June, aligning with the epidemiological pattern of measles in northern Vietnam, which typically surges during the dry season, often referred to as the spring-summer season.

Most measles cases admitted to NCH are under 5 years old, which aligns with reports of community-based measles cases in the northern region in 2018 from an NIHE study, with nearly 65% of cases in this age group [34].

Vietnam has been organising regular vaccination campaigns and measles elimination efforts in recent years, with high vaccination coverage and strengthened surveillance, making indigenous measles transmission rare. However, despite high coverage at national and provincial levels, there remain pockets of under-immunised populations in remote, border, island, and hard-to-reach communities. As a result, when an imported measles case occurs, these susceptible groups are at risk of contracting and spreading the disease. The measles vaccination rates were exceptionally low in all groups, with only 9.1% of patients older than 9 months having received at least one dose of MCV. Notably, a majority of the hospital-acquired cases were unvaccinated. This lack of vaccination might be attributed to their pre-existing health conditions and medical history, causing delays in vaccination as per the recommended schedule. In practice, children with prolonged illnesses often experience extended postponements of vaccination. This is a significant concern and underscores the need to enhance vaccination coverage, especially among the most vulnerable age groups, particularly children with underlying health conditions or immunodeficiency, to protect them from this highly contagious disease. This calls for a more flexible, evidence-based vaccination approach—supported by legal guidelines and equipped with adequate measures to manage adverse events following immunization (AEFI)—for these special populations. In Vietnam, vaccination staff are often overly cautious, frequently delaying vaccines for children with even minor health issues (e.g., mild cough or runny nose), even when such symptoms do not warrant postponement.

Despite the very low MCV coverage among hospital-acquired cases, the number of nosocomial measles cases was not as high as might have been expected. This can be partly explained by the infection prevention and control (IPC) measures that were promptly implemented during the outbreak, including strict isolation, use of personal protective equipment, and restricted visitation. Furthermore, not all unvaccinated patients were directly exposed to an infectious measles case, as the risk of transmission depends on ward location, patient flow, and the duration of overlap with infectious individuals. These factors likely contributed to mitigating in-hospital transmission even among susceptible patients.

However, it is important to note that this outbreak occurred at the National Children's Hospital, the leading tertiary pediatric hospital in Vietnam's capital, where IPC measures are relatively advanced and strongly emphasized compared with responses that might be expected in other hospitals. What is especially critical is the development of a comprehensive strategy that goes beyond outbreak response. This includes achieving and maintaining a high level of herd immunity by increasing coverage of the second dose of measles-containing vaccine (MCV2) and recommending that women receive measles vaccination before pregnancy. Breastfeeding seems to support the sustained retention of immunity conferred by the measles vaccine [35].

The recommendation to administer MCV1 to high-risk infants under 9 months of age constitutes an important strategy for reducing both the mortality and morbidity attributable to measles [36]. This highlights the importance of tailored preventive measures for infants too young for routine immunization, alongside efforts to strengthen population-level immunity. Such strategies echo lessons from past measles outbreaks in Vietnam, despite reported high immunization rates in the Expanded Program on Immunization.

A concerning observation was the high percentage of pediatric patients under 9 months of age who were not yet eligible for a measles-containing vaccine (MCV) but nevertheless became infected with measles. This could be attributed to the absence or waning of maternal antibodies, due to the mother's lack of immunity through vaccination (received prior to pregnancy) or past natural measles infection. It may also have been influenced by infant feeding practices, such as the absence of breastfeeding, although this information was not available in the current dataset. Moreover, several studies have demonstrated that maternally derived immunity wanes rapidly within the first few months of life [37].

Hanoi registered the highest number of community-acquired measles cases, with over 500 hospitalizations, not including suspected or hospital-acquired cases. This pattern aligns with common observations during extensive measles outbreaks, where cases tend to cluster in densely populated cities and industrial regions. Hanoi, as the capital of the country, is a bustling, densely inhabited city with significant population mobility, creating an environment conducive to measles transmission. This situation is further complicated by challenges in vaccination management.

The Delta region accounted for over 70% of all cases across all groups. Similarly, within the community-acquired cases, the Delta region also comprised more than 70%. This can be explained by the fact that this region includes Hanoi, as previously explained. Additionally, this region is adjacent to Hanoi, the most economically developed and bustling area in the North, with convenient transportation, which could make accessing treatment at NCH for this region understandable. However, it's necessary to conduct further assessments of the actual measles cases in the community in this area, along with the coverage of MCV in the region to make an accurate assessment of the measles situation here.

Most cases were community-acquired measles, yet nearly 40% of confirmed measles cases were linked to hospital settings. Among them, over 7% were distinctly identified as hospital-acquired, indicating potential risks within healthcare facilities and the necessity for robust infection control measures to curtail in-hospital transmission. Nosocomial transmission is quite common with infectious diseases like measles, associated with several contributing factors such as delayed diagnosis, inadequate isolation areas, and transmission between healthcare workers, patients, and caregivers. It's essential to emphasize that hospital-related transmission mentioned here pertains not only to the National Children's Hospital (NCH) but also encompasses lower-level hospitals and private clinics where cases sought prior medical attention. The annual incidence rate of hospital-acquired or suspected hospital-acquired measles cases peaked in 2017 and subsequently significantly declined in the following two years, suggesting that hospitals have implemented more sensitive diagnostic procedures, early detection, improved isolation practices, and better infection control measures. However, this also underscores the dynamic nature of measles transmission in healthcare environments, demanding constant vigilance and adaptable infection control strategies.

Tragically, the study recorded ten fatalities, with 70% of these deaths occurring in patients initially admitted for other illnesses but later diagnosed with measles within the hospital or suspected of acquiring it in the hospital. This highlights the severity of measles as a secondary infection, especially among those with pre-existing health conditions, as well as vulnerabilities in the IPC system.

Bronchitis and pneumonia were the most common complications across all sources of infection. Pneumonia, in particular, was recorded in an alarming 90% of the deaths and was the most frequently reported complication among hospital-acquired cases. This emphasizes the importance of monitoring and managing complications, especially in cases of hospital-acquired measles.

Co-infection with other pathogens, including RSV, adenovirus, and pertussis, was statistically significant among hospital-acquired cases. This highlights the complexity of measles cases within the hospital setting and underscores the need for stringent infection control measures to minimize co-infection risk and reduce the burden of hospital-acquired cases.

3.13 Limitation

This study is subject to certain limitations. Firstly, it did not include suspected cases tested negative, potentially resulting in the loss of valuable data. Secondly, due to the retrospective nature of the study and the restricted access to information inherent in secondary data, critical details regarding clinical characteristics, nutritional status, vitamin A delivery, isolation protocols, infection prevention strategies, and vaccination campaigns was lacking. The study data focused on pediatric patients and did not encompass data concerning healthcare personnel or caregivers at the hospital who may have concurrently contracted measles, nor did it explore the epidemiological connections between these different groups. Moreover, due to limitations in exposure documentation, case classification based on the study definitions may be subject to misclassification; specifically, we cannot entirely rule out the possibility of unrecognized in-hospital exposure among cases classified as community-acquired, as well as overlap between suspected hospital-acquired and community-acquired cases. This study used retrospective data extracted from routine hospital records, which were not designed to establish the temporal sequence of infections. As such, we cannot determine whether measles preceded or followed other respiratory infections, such as RSV, adenovirus, or pertussis. The observed associations may reflect co-circulation of multiple pathogens in a hospital setting with suboptimal infection prevention and control (IPC), rather than any causal relationship. We also cannot exclude the possibility that these associations simply indicate an increased burden of nosocomial transmission of respiratory viruses. Lastly, there exists the possibility of recall errors in participant interviews regarding their vaccination status and exposure factors. These limitations could impact the comprehensiveness and accuracy of the findings.

3.14 Recommendation

As a result of the evidence from this study, we propose the following recommendations to enhance our understanding of measles transmission and mitigate it in hospital settings in Vietnam:

Conduct further investigations: In-depth studies are imperative to unravel the intricacies of measles transmission within hospitals. These investigations should encompass comprehensive analysis of infection dynamics, potential sources of outbreaks, and the effectiveness of current infection control measures. Additionally, pinpointing areas in the community characterized by low immunization coverage is essential. Understanding the virus's spread in these contexts will inform targeted interventions and vaccination campaigns. While the waning of maternal antibodies in infants under 9 months is well documented in the literature, additional context-specific assessments - particularly in the Vietnamese population - may help clarify the extent to which maternal immunity and other contributing factors, such as maternal vaccination status and infant feeding practices, influence susceptibility in this unvaccinated age group.

Enhance infection control measures: Hospitals must prioritize robust infection control and triage practices. This involves stringent isolation and containment protocols, along with adequate protective gear for healthcare personnel. Additionally it is imperitive to conduct regular training and awareness programs, to enforce IPC protocols to ensure compliance and understanding among staff at all levels.

Improve diagnosis and treatment: Further research is needed to optimize the diagnostic process for early detection and timely isolation, preventing cross-infections during the waiting period for diagnostic confirmation. This should also encompass a focus on identifying the specific risk factors relevant to healthcare personnel, patients, and caregivers in diverse and crowded hospital settings, particularly in emergency departments and infectious disease units.

Vaccination Practice: To minimize the risk of illness and severe complications among pediatric patients, particularly those with underlying health conditions or weakened immune systems, if they are of vaccination age, meaning they are at least 9 months old, it is essential to recommend vaccination and engage in community outreach to raise awareness of this issue. Checking vaccination status on hospital admission and offering MCV when not contraindicated should be considered as part of routine practice. Pre-conception screening for measles vaccination status should also be encouraged, especially for women of reproductive age.

Risk communication: Risk communication strategies should be implemented during measles outbreaks to ensure timely and clear information for healthcare workers, patients, families, and the general public.

3.15 Conclusion

In conclusion, this study provides evidence suggesting measles transmission within a hospital environment, with a particular focus on unvaccinated pediatric patients. It is noteworthy that the rate of hospital-acquired measles cases decreased over the years of the period studies. The high fatality rate observed among cases associated with hospital-acquired measles, along with the notable complication of pneumonia, underscores the gravity of this issue. The significant co-infection of measles with other pathogens such as RSV, adenovirus, and pertussis, signifying the complexity of measles cases in a hospital setting.

These findings stress the importance of adopting a comprehensive approach to measles prevention, which should encompass improved vaccination campaigns to ensure broader coverage, robust and adaptable infection control measures within healthcare facilities, and thorough monitoring and management of complications. By applying these insights and combining them with the wealth of knowledge gained from responding to outbreaks worldwide, we can better protect vulnerable populations and work towards a world where the scourge of measles is no longer a threat.

3.16 References

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3.17 Appendices

3.17.1 Appendix 3.1. Literature review

Table 3.3. *Summaries of 15 documents reviewed*

Author, year (Ref)	Study design	Setting	Study size	Results
Pampaka, D., et al. (2023) [17]	Outbreak investigation	An interregional outbreak, in Spain, November 2017 to July 2018	154 cases	**Nosocomial outbreak of measles:** Yes, 42.2% - At least six healthcare facilities and 41 HCWs and support personnel were affected. - Potential exposure areas: waiting areas, emergency departments, and pediatric wards. **Index case:** an imported case travelling to the Valencian Community. 148 were **laboratory-confirmed** and six **epidemiologically linked.** **Age:** 40.3% adults aged 30-39 (n = 62) years. Hospitalised 40.3% and 22.7% presented complications. 66.7% unvaccinated including 11 infants (≤ 1 year) not yet eligible for vaccination. Nearly 20% cases did not have the typical symptoms. **Control measures:** - Cases were isolated for 4 days after symptom onset. - Contact tracing identified susceptible contacts (unvaccinated or with unknown vaccination status). - Contacts' immunization status was assessed, and MMR vaccines were offered to those unvaccinated or partially vaccinated.

Author, year (Ref)	Study design	Setting	Study size	Results
				- In healthcare settings, recommendations for healthcare worker vaccination were published, and susceptible workers were identified and vaccinated. - Healthcare workers in contact with cases who didn't receive vaccination were excluded from work for at least 18 days. - Information about measles was shared within healthcare networks to raise awareness. - Reports and press releases were prepared and shared with the health community and the public. **Recommendations:** - For cases with atypical clinical symptoms of measles, testing should be conducted without regard to vaccination status. - Raising awareness about measles. - Enhancing vaccination coverage among unvaccinated groups and healthcare personnel.
So, H. Kim, et al. (2023) [24]	Cross-sectional study	A Local Children's Hospital in Korea, 2019	20 confirmed measles cases: 15 infants under 4 years old, 5 adults	**Nosocomial outbreak of measles: Yes** **Age:** The index patient was a 7-month-old girl with a recent history of travel to Vietnam. - 55% were infants (0-11 months of age), - 15% were aged 1-3 years, - 5% was aged 4 years, - 25% were adults. **Vaccine status:** - 75% patients did not have a history of measles vaccination, - 25% had received only one vaccine dose. **Recommendations:**

Author, year (Ref)	Study design	Setting	Study size	Results
				- The importance of prompt application of infection control measures in susceptible environments, including hospitals. - Age-appropriate vaccination and providing information on infectious diseases to international travelers and multicultural families in Korea is vital.
Song, K., et al. (2022) [18]	Outbreak investigation	A population with high vaccine coverage: Korea, 2019	26 confirmed cases	**Background: high population immunity** **Nosocomial outbreak of measles: Yes** - 22/26 were HCWs, four inpatients - Aged 18-28 years - 25 had MMR vaccine (46% two doses; 50% one dose), - 62% had positive IgG of measles prior to measles diagnosis. - ARs were higher among HCWs aged < 30 years (1.88%), especially in the subgroup under 25 years of age (2.22%) **Control measures:** - Work restrictions for seronegative 9.4% HCWs - Administration of the MMR vaccine (207 HCWs) or intravenous immunoglobulin (2 HCWs and 11 inpatients), - Enhanced health surveillance of HCWs, - Mandatory assessment of patients with measles-like symptoms at the infectious diseases screening units. **Recommendations:** - The importance of stronger vaccination policies, particularly among young HCWs. - Enhanced surveillance of HCWs and patients to rapidly detect measles-like symptoms at a prodromal phase.

Author, year (Ref)	Study design	Setting	Study size	Results
Woods, S., et al. (2021) [38]	Observation	University Hospital Limerick, Ireland, 2018	42 confirmed cases	**Nosocomial outbreak of measles: Yes** - Imported case from the Middle East diagnosed with measles after a lengthy ED wait. - Over 65% of cases aged 15 or older. - 7 from direct contact, others hospital transmission. - Only 29% of hospital doctors had complete vaccination records. **Control measures:** - Offered prophylactic measures for healthcare workers; some did not attend. **Recommendations:** - Highlighted the need for efficient patient identification and isolation in busy ED.
Rizkalla, C., et al. (2020) [39]	Outbreak response	Urban Emergency Department , Maimonides Medical Center, New York City, USA, 2018	69 laboratory confirmed measles cases	**Key challenges during the measles outbreak:** - Limited isolation rooms, risking inadequate isolation. - Prioritizing measles cases, affecting patient flow. - Limited access to guidance in remote areas. - 28-day child quarantine, posing challenges for working parents. - High call volume and diverse patient needs, requiring time and interpretation. - Complex decisions due to vaccine-induced rashes and exposures. - Space limitations led to challenges in isolating fever cases. - Health worker status confusion between CDC and local authorities. - Ambulance transport complexities for infected patients, with evolving standards. **Key proactive measures in response to the measles outbreak:**

Author, year (Ref)	Study design	Setting	Study size	Results
				- Updated MMR vaccination recommendations for infants in high-prevalence areas: receive their first MMR vaccine at 6 months, with the second dose available just one month after the initial vaccination. - Implementation of infant screening and MMR vaccination in the pediatric ED. - Sharing experiences to assist other healthcare settings in infection control. - Focus on reaching vulnerable children for vaccination during the outbreak.
Vink, J. P., et al. (2020) [19]	Outbreak investigation	Two hospitals and a local community across two countries, South London in 2018	34 confirmed cases	- 34 cases in two hospitals and a local community across two countries. - Spread between retail workers and healthcare staff. - Measles transmission occurred in an under-vaccinated Traveller community, re-establishing endemic UK transmission. **Recommendations:** - Emphasizes the need for occupational health policies for non-clinical hospital staff. - Highlights the potential for measles to spread without herd immunity.
Kohlmaier, B. , et al. (2020) [25]	Retrospective study	A paediatric university hospital, Austria, 2017	13 laboratory confirmed measles cases 23 clinicians	**Nosocomial outbreak of measles: Yes** - Unknown **source of infection** **Age:** a median age of 12 months (range: 2 months–30 years) - 46% were infants under 1 year old. - ***69.2% were hospital acquired cases*** **Vaccine status:** - 23% were not eligible for rountine vaccination

Author, year (Ref)	Study design	Setting	Study size	Results
				- 61.2% were unvaccinated - 7.7% had received only one vaccine dose. - (7.7%) The paediatrician in training was fully vaccinated but received immuno- suppressive treatment as a child. **Clinical practice:** - 56.5% doctors did not recognise typical measles - 52.2% doctors had never encountered a patient with measles before. **Recommendations:** - The need to establish regular training programmes about measles, including diagnostic pitfalls in paediatric hospitals.
Cornelissen, L., et al. (2020) [29]	Outbreak investigation	Belgium early 2017	289 cases	**Nosocomial outbreak of measles: Yes** - 12% were HCWs, and nosocomial spread played a significant role in the outbreak. - 53% cases were 15 years or older. - 41% were not vaccinated, 29% of unvaccinated cases should have received at least one vaccine dose as per national guidelines. - 21% of cases showed atypical clinical symptoms. - 43% of cases required hospitalization. - 46% were hepatic disorders as the most common complications. **Lessons learned:** - Older age, atypical symptoms, and complications like hepatitis could delay measles diagnosis. - Clinicians should maintain a high suspicion for measles in individuals presenting with a rash.

Author, year (Ref)	Study design	Setting	Study size	Results
				- To achieve the elimination target, intensified catch-up vaccination campaigns should focus on young adults and healthcare workers.
Fu, J., et al. (2019) [20]	Descriptive analysis	in a Chinese medicine hospital, Beijing, in March 2018	11 measles cases in HCWs	**Nosocomial outbreak of measles: Yes** - Median age: 26 years (range: 21-53), with 36.4% males. - 10/11 cases were unvaccinated or had unknown vaccination status, - 2 HCWs occurred in emergency departments. No inpatients, mostly 55 years or older, were infected. **Control measures:** - Response activities included isolating cases and enhancing health surveillance. - 2234 doses of MCV covered 93.3% of susceptible health workers, with 973 doses for susceptible individuals in households and the community. - Lack of MCV documentation before the outbreak was a risk factor for measles. **Recommendation:** - Recommends 2-dose MCV for HCWs.
Teng, S. S., et al. (2019) [28]	a retrospective observational cohort study	a high-volume Pediatric Emergency Department (ED) in Singapore, 2010-2016	277 hospitalized patients	- 63.9% were not initially isolated at ED triage, and 33.2% were not admitted to isolation wards. - 27.1% of microbiologically confirmed measles cases had no rash at initial ED presentation, seeking care earlier (average 3.1 days) than those with a rash (average 4.8 days). - Patients without a rash were usually younger and admitted for poor feeding. **Lessons learned:**

Author, year (Ref)	Study design	Setting	Study size	Results
				- Challenges in isolating pediatric patients with nonspecific symptoms highlight the need for global vaccination to boost herd immunity against measles.
Sá Machado R et al. (2018) [21]	Outbreak investigation	A healthcare setting in Porto, Portugal, 2018.	211 cases linked to the hospital	**Nosocomial outbreak of measles: Yes** - 96 confirmed cases (45.5%) and 82 probable cases (38.9%). - 88.1% adults from 18-49 years old, 2.4% children. - 96 confirmed cases included: 90% healthcare workers (HCW), 1 case was hospitalised patient, 69.8% were vaccinated with 2 doses of MCV. **Control measures:** - Hospital activated an Emergency Response Team (ERT) in collaboration with local public health. - Hospital established an isolation area. - Implemented precautions, including portable laminar flow high efficiency particulate air (HEPA) filtration, mask usage for HCW in contact with cases, and reinforced hand hygiene. - Administered Post-exposure prophylaxis (PEP) within 72 hours to 1,132 susceptible HCW and patients. - Local public health teams conducted case investigations, contact tracing, and control measures. - Engaged in brief media communications.
Jia, H., et al. (2018) [22]	a retrospective search	Hospital W, Xinjiang Autonomous Region, China, December	19 measles cases in HCWs	**Nosocomial outbreak of measles: Yes** - Aged 18 to 45 years. - Index case was a 25-year-old neurology nurse who continued working and living with colleagues during her infectious period. - Only 2/19 had been vaccinated against measles; 16 (84.2%) had an unknown vaccination status.

Author, year (Ref)	Study design	Setting	Study size	Results
		2015 and January 2016.		**Control measures:** - 68% of 890 HCWs receiving the vaccine. - A survey found that 41% of HCWs had prior MCV vaccination, and 56% had good knowledge of measles. **Lessons learned:** - The outbreak resulted from low MCV coverage, limited HCW measles knowledge, delayed case reporting, and inadequate management. - Underlines the importance of training and vaccinating healthcare workers to prevent measles transmission among them.
Porretta, A., et al. (2017) [27]		An Italian hospital, in Italy, February-April 2017	35 confirmed cases	- An outbreak involved 35 individuals, including healthcare workers, support personnel, visitors, and community contacts. - Late diagnosis of the first case and transmission in the emergency department sustained the outbreak. **Control measures:** - Identifying exposed contacts and offering vaccination to hospital personnel and patients for each confirmed case. - Reviewed personnel immunization and provided vaccines. - A hospital procedure directed cases with measles-like symptoms to the infectious diseases unit. - Regular communication between the local health authority and the hospital's epidemiology unit identified additional cases among hospital visitors.
Zhang, D. L., et al. (2015) [23]	Outbreak investigation and Case – control study	Hospital X, Xiangshan County, Zhejiang	108. 45 measles cases of	**Nosocomial outbreak of measles: Yes** - Age: 91.1% were adults (ranged 23-51 years) who had unknown vaccination histories; the other cases were infants younger than 8 months of age.

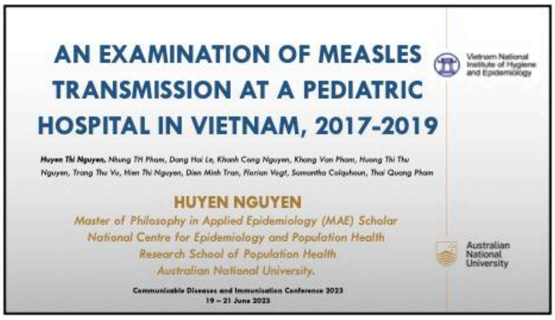
Author, year (Ref)	Study design	Setting	Study size	Results
		Province, in eastern China, 2014	the outbreak 109. Case-control study: 20 cases: 40 controls 110. 307 residual serum specimens	- During the patients' illness onset: 28.9% cases visited to Hospital X, 53.8% of which visited to IV room in Hospital X. - During the period of communicability: 93.3% visited to Hospital X and 85.7% of them shared the same IV room. The case-control study showed major risk factors to be a visit to Hospital X (OR(MH)=7.3, 95% CI: 1.8-30.7) and treatment in an IV room in Hospital X (OR(MH)=11.0, 95% CI: 1.3-96.1). The seroprevalence survey showed that 88.8% of adults had measles IgG antibodies, and that 100% of children 2-19 years of age were seropositive.
Corbin, V., et al. (2013) [26]	an observational review	The University Hospital of Clermont-Ferrand, France, 2009-2011	113 adult in- and outpatients	**Nosocomial outbreak of measles: Yes** - 71 (62.8%) required hospitalization, with various complications, including pneumonia, diarrhea, liver enzyme elevation, thrombocytopenia, and one case of encephalitis, no fatalities. - 19 cases affected healthcare workers, including five hospital-acquired infections. - 81.4% were unvaccinated. - The peak of the 2011 measles re-emerging epidemic occurred when non-immunized adults were affected.

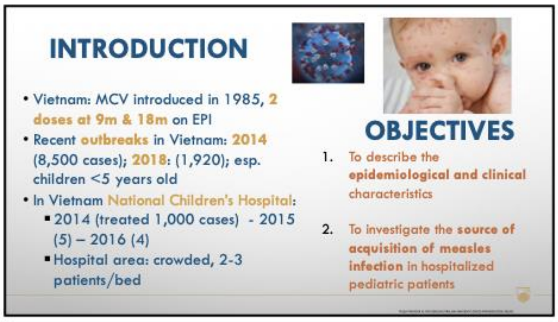
3.17.2 Appendix 3.2. Conference presentations

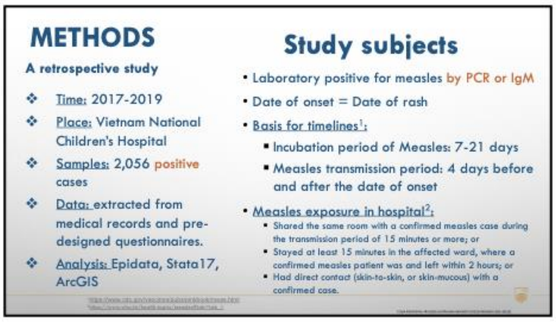
Conference presentation 1

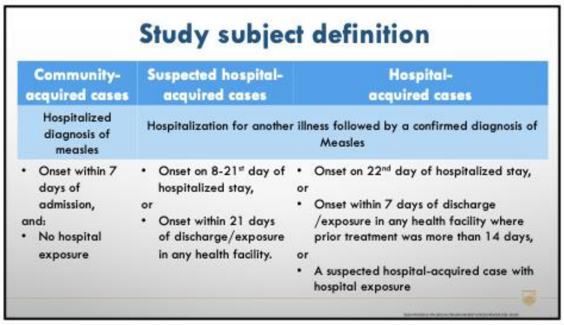
Presentation at:

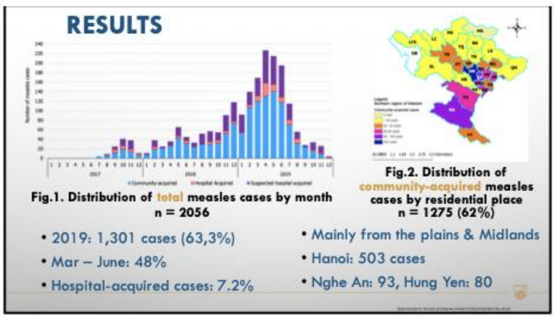
Huyen Thi Nguyen, *Nhung TH Pham, Dang Hai Le, Khanh Cong Nguyen, Khang Van Pham, Huong Thi Thu Nguyen, Trang Thu Vu, Hien Thi Nguyen, Dien Minh Tran, Florian Vogt, Samantha Colquhoun, Thai Quang Pham. "An examination of measles transmission at a pediatric hospital in Vietnam, 2017-2019". Oral long presentation (10 minutes),* ***Communicable Diseases and Immunisation Conference 2023 (CDIC2023)****,* ***19 – 21 June 2023 in Perth, Western Australia.***

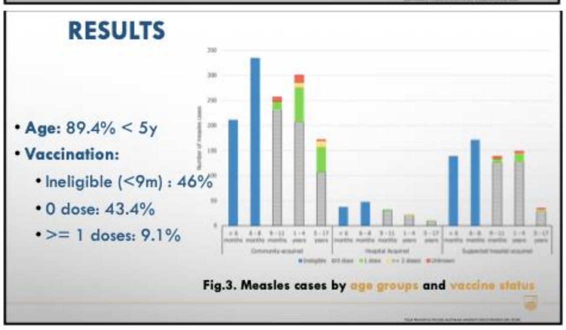












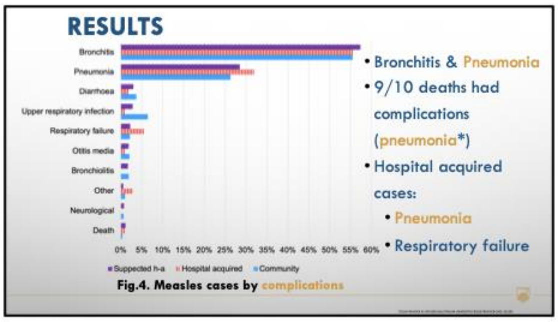


Fig.4. Measles cases by complications

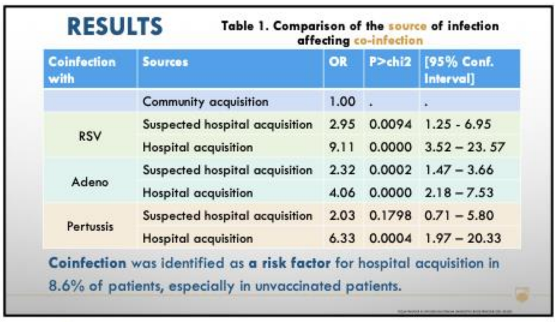
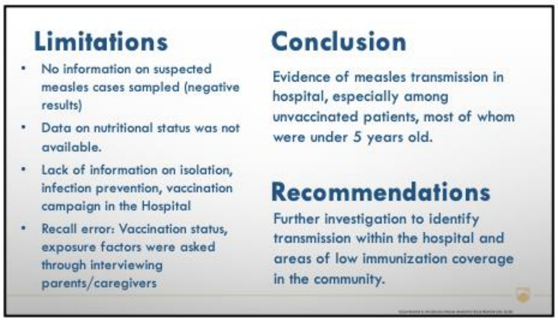


Table 1. Comparison of the source of infection affecting co-infection

Coinfection with	Sources	OR	P>chi2	[95% Conf. Interval]
	Community acquisition	1.00	.	.
RSV	Suspected hospital acquisition	2.95	0.0094	1.25 - 6.95
	Hospital acquisition	9.11	0.0000	3.52 – 23. 57
Adeno	Suspected hospital acquisition	2.32	0.0002	1.47 – 3.66
	Hospital acquisition	4.06	0.0000	2.18 – 7.53
Pertussis	Suspected hospital acquisition	2.03	0.1798	0.71 – 5.80
	Hospital acquisition	6.33	0.0004	1.97 – 20.33

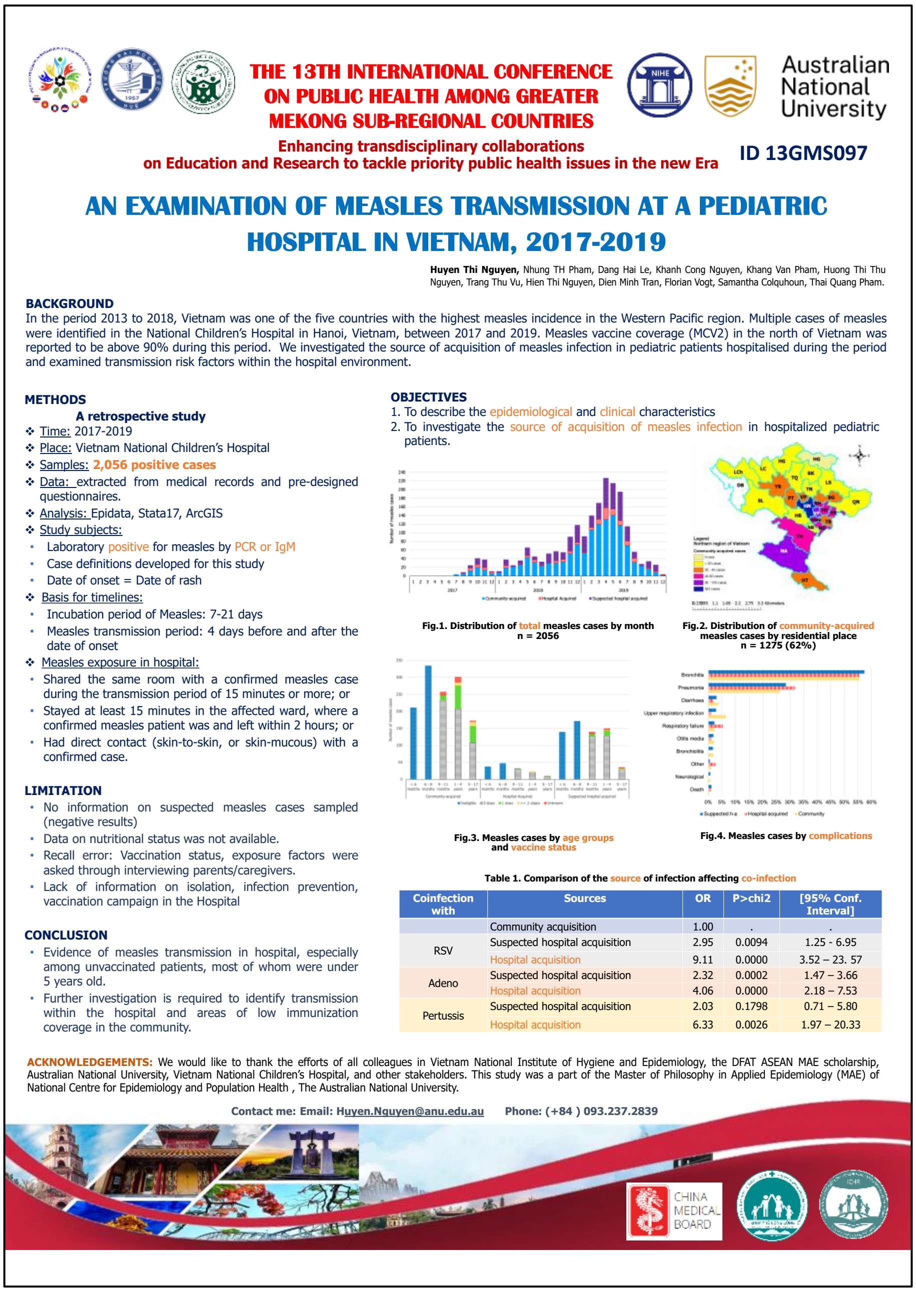
Coinfection was identified as **a risk factor** for hospital acquisition in 8.6% of patients, especially in unvaccinated patients.



Conference presentation 2

Presentation at:

Huyen Thi Nguyen, *Nhung TH Pham, Dang Hai Le, Khanh Cong Nguyen, Khang Van Pham, Huong Thi Thu Nguyen, Trang Thu Vu, Hien Thi Nguyen, Dien Minh Tran, Florian Vogt, Samantha Colquhoun, Thai Quang Pham. "An examination of measles transmission at a pediatric hospital in Vietnam, 2017-2019".* ***Poster presentation, The 13th International Conference on Public Health among the Greater Mekong Subregion countries 2023 (GMS-13), 01 – 02 July 2023 in Hue, Vietnam.***



THE 13TH INTERNATIONAL CONFERENCE ON PUBLIC HEALTH AMONG GREATER MEKONG SUB-REGIONAL COUNTRIES

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ID 13GMS097

AN EXAMINATION OF MEASLES TRANSMISSION AT A PEDIATRIC HOSPITAL IN VIETNAM, 2017-2019

Huyen Thi Nguyen, Nhung TH Pham, Dang Hai Le, Khanh Cong Nguyen, Khang Van Pham, Huong Thi Thu Nguyen, Trang Thu Vu, Hien Thi Nguyen, Dien Minh Tran, Florian Vogt, Samantha Colquhoun, Thai Quang Pham.

BACKGROUND

In the period 2013 to 2018, Vietnam was one of the five countries with the highest measles incidence in the Western Pacific region. Multiple cases of measles were identified in the National Children's Hospital in Hanoi, Vietnam, between 2017 and 2019. Measles vaccine coverage (MCV2) in the north of Vietnam was reported to be above 90% during this period. We investigated the source of acquisition of measles infection in pediatric patients hospitalised during the period and examined transmission risk factors within the hospital environment.

METHODS

A retrospective study

- Time: 2017-2019
- Place: Vietnam National Children's Hospital
- Samples: **2,056 positive cases**
- Data: extracted from medical records and pre-designed questionnaires.
- Analysis: Epidata, Stata17, ArcGIS
- Study subjects:
  - Laboratory positive for measles by PCR or IgM
  - Case definitions developed for this study
  - Date of onset = Date of rash
- Basis for timelines:
  - Incubation period of Measles: 7-21 days
  - Measles transmission period: 4 days before and after the date of onset
- Measles exposure in hospital:
  - Shared the same room with a confirmed measles case during the transmission period of 15 minutes or more; or
  - Stayed at least 15 minutes in the affected ward, where a confirmed measles patient was and left within 2 hours; or
  - Had direct contact (skin-to-skin, or skin-mucous) with a confirmed case.

LIMITATION

- No information on suspected measles cases sampled (negative results)
- Data on nutritional status was not available.
- Recall error: Vaccination status, exposure factors were asked through interviewing parents/caregivers.
- Lack of information on isolation, infection prevention, vaccination campaign in the Hospital

CONCLUSION

- Evidence of measles transmission in hospital, especially among unvaccinated patients, most of whom were under 5 years old.
- Further investigation is required to identify transmission within the hospital and areas of low immunization coverage in the community.

OBJECTIVES

1. To describe the epidemiological and clinical characteristics
2. To investigate the source of acquisition of measles infection in hospitalized pediatric patients.

Fig.1. Distribution of total measles cases by month n = 2056

Fig.2. Distribution of community-acquired measles cases by residential place n = 1275 (62%)

Fig.3. Measles cases by age groups and vaccine status

Fig.4. Measles cases by complications

Table 1. Comparison of the source of infection affecting co-infection

Coinfection with	Sources	OR	P>chi2	[95% Conf. Interval]
	Community acquisition	1.00	.	.
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ACKNOWLEDGEMENTS: We would like to thank the efforts of all colleagues in Vietnam National Institute of Hygiene and Epidemiology, the DFAT ASEAN MAE scholarship, Australian National University, Vietnam National Children's Hospital, and other stakeholders. This study was a part of the Master of Philosophy in Applied Epidemiology (MAE) of National Centre for Epidemiology and Population Health , The Australian National University.

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Chapter 4. Evaluation of a surveillance system

Evaluating the Japanese Encephalitis (JE) Disease surveillance system in Son La province, Vietnam, 2016-2022

List of Abbreviations – Chapter 4

ANU	Australian National University
MAE	Master of Applied Epidemiology Program
NIHE	National Institute of Hygiene and Epidemiology
COVID-19	Coronavirus Disease 2019
JE	Japanese Encephalitis
JEV	Japanese Encephalitis virus
WHO	World Health Organization
EPI	Expanded Programme on Immunization
NEPI	National expanded program on Immunization
CDC	Centers for Disease Control and Prevention
NEDSS	National Electronic Disease Surveillance System
US CDC	United States' Centers for Disease Control and Prevention
AES	Acute Encephalitis syndrome
JEVAX	Japanese Encephalitis vaccine
VPDS	Vaccine Preventable Diseases Surveillance

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4.1 Prologue

4.1.1 My role

In April 2023, NIHE conducted an evaluation of Japanese Encephalitis (JE) surveillance and responses activities in Son La, Vietnam. Our team went to Son La province for stakeholder meetings and interviews on 19-21 April 2023.

As a primary investigator for this project I developed the study proposal and engaged with a multidisciplinary team. I was involved in data collection, analysis, and interpretation to assess the strengths and weaknesses of the Japanese Encephalitis (JE) sentinel surveillance system in Son La province. Through examination of quantitative and qualitative data, I contributed to the evaluation of the system attributes such as simplicity, data quality, flexibility, and sensitivity.

Additionally, I collaborated with local health authorities and stakeholders to ensure the successful execution of in-depth interviews follow by delivery of guided questionnaire (Appendix 4.3), to draw insights from key stakeholders and system managers and users expertise and experience. My engagement extended to the organization of interview transcripts and the extraction of information, which subsequently aided in generating a comprehensive evaluation of the surveillance system's various facets.

4.2 Lesson learned

This was the first time I have used a comprehensive approach to evaluate a surveillance system, although I've been working with the infectious disease surveillance system in South Vietnam for more than three years prior to enrolling the MAE program. I have learned the process of conducting an evaluation in this field, selecting attributes of a surveillance system in a prioritized manner, as well as using tools to assess them.

One of the most significant lessons I've learned is the dynamic nature of surveillance systems. Witnessing how the system adapts to changing conditions, such as the impact of the COVID-19 pandemic, underscored the necessity of flexibility and resilience in public health strategies. Moreover, I've realized the critical role of accurate data in guiding decision-making and policy formulation. The process of meticulously assessing attributes like data quality, simplicity, and sensitivity has illuminated the crucial role of robust surveillance in preventing and managing disease outbreaks.

Another important point to remember is that no system is perfect when it's first created. It's essential to understand how it works in the real world, find the best ways to make it work, and identify the challenges. All of this helps us come up with practical ideas to make the surveillance system better, more complete, and more responsive.

4.3 Public health impact

This evaluation of the JE surveillance system in Son La province holds some significant implications for public health in Vietnam.

Firstly we looked at how well the general surveillance system has helpsed to reduce the number of people getting sick and dying from JE. We also tried to figure out how many cases were prevented because of quick actions and good public health efforts.

Moreover, the finding of the evaluation will provide a foundation for evidence-based policy adjustments, fostering a proactive approach to public health management; strengthening active disease surveillance.

By comprehensively assessing the attributes of the system, the evaluation enabled a thorough understanding of the strengths and areas for improvement e.g., recommending system enhancements to contribute to more effective disease dectection, faster response times, and improved data quality. Driving informed decision-making and targeted interventions and strategies that can substantially enhance disease surveillance and response, to prevent the spread of infectious diseases can act to minimize morbidity and mortality rates, and alleviate the burden on healthcare resources.

4.4 Acknowledgements

I would like to express my sincere appreciation to my academic and field supervisors, Assoc. Prof. Samantha Colquhoun, Assoc. Prof. Pham Quang Thai, and Dr. Nguyen Cong Khanh, for their unwavering support throughout this project. I also wish to acknowledge MD. Le Hai Dang, an epidemiologist and the focal point person for the JE surveillance system at NIHE, as well as the stakeholders from NIHE, Son La CDC, and Son La Provincial General Hospital, for their invaluable contributions to this evaluation.

4.5 Master of Philosophy in Applied Epidemiology core requirements

✓ Evaluation of a surveillance system

4.6 Abstract

Background:

This project focuses on evaluating the Japanese Encephalitis (JE) surveillance system in Son La province, Vietnam. JE is a mosquito-borne viral infection, primarily affecting the central nervous system and causing severe neurological complications. Son La is a high-risk area for JE, and surveillance is essential for early detection and response.

Method:

Data from the National Electronic Disease Surveillance System (NEDSS) and in-depth interviews with local healthcare workers were analyzed to assess the strengths and weaknesses of the surveillance system. The study evaluated four attributes following the guide of US CDC: Simplicity, Data quality, Flexibility and Sensitivity.

Results:

From 2016 to 2022, 83 JE cases were reported via NEDSS, with 77% occurring in children under 18 and nearly 10% resulting in death. Over half of the cases were among the Thai ethnic group, and 88% occurred between June and August. The system was generally considered simple to use, although staff noted challenges with time-consuming data entry and limited feedback. Data quality was affected by inconsistencies, including a 28% discrepancy between laboratory results and diagnostic classifications, as well as unreliable vaccination information due to recall bias. The system demonstrated moderate flexibility, having adapted during the COVID-19 pandemic despite being hindered by high staff turnover. Sensitivity was low, with only 74.1% of community-confirmed cases captured by the system, partly due to reliance on major hospitals and underreporting from lower-level facilities.

Discussion:

A low rate of Sensitivity data has indicated the potential for missed cases, which could lead to delays in detecting JE outbreaks or cases and responding to them. Moreover, the recent high turnover in staffing, particularly during the COVID-19 pandemic, has underscored the necessity for enhanced data completeness, quality, and community-level surveillance. Additionally, the integration of JE surveillance with other health priorities was also discussed.

Conclusion:

The JE surveillance system in Son La plays a crucial role in detecting and responding to JE cases. However, there are challenges related to data completeness, quality, and staffing. Despite these challenges, the system remains a valuable tool for monitoring and controlling JE in the region.

Recommendations:

A recomendation to improve data completeness would be to addressstaffing challenges and providing adequate training for all staff involved in data collection, management, analysis and reporting. An addtional recommendation arising from this review is to expand surveillance efforts beyond the major hospitals, which would improve coverage and provide a more comprehensive report of JE cases at the community level.

4.7 Introduction of Japanese Encephalitis

Japanese Encephalitis is a mosquito-borne illness caused by the flavivirus JE virus (JEV). JEV is responsible for the majority of viral encephalitis cases in Asian and Western Pacific countries, accounting for approximately 68,000 clinical cases annually [1].

Culex mosquito species in general and particularly Culex tritaeniorhynchus which are prevalent in rural and agricultural areas, are the main vector to be infected with JEV, which are then then transmitted to humans through bites. These mosquitoes acquire the virus by feeding on infected birds or pigs, which serve as reservoir hosts for the virus. Once infected, mosquitoes can transmit the virus to humans, further perpetuating the cycle (Figure 4.1). Humans infected with JEV do not develop a sufficient level of the virus in their bloodstream to infect mosquitoes that bite them ie they are dead end hosts. This cycle is known as an enzootic cycle, involving animals (pigs and/or water birds) and mosquitoes [2].

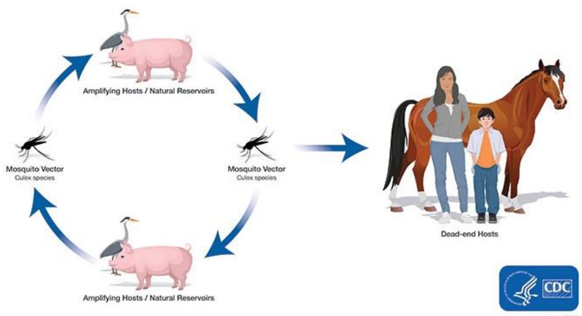

Figure 4.1. Japanese Encephalitis virus transmission cycle

Figure 4.2. Geographic distribution of Japanese Encephalitis virus

Significant JE outbreaks take place approximately every 2 to 15 years [3]. The transmission of JE becomes more pronounced during the rainy season when vector populations increase. The expansion of JEV into new regions has been linked to the growth of agriculture and the intensive cultivation of rice, often supported by irrigation programmes.

JEV transmission is endemic in 24 countries within the WHO South-East Asia and Western Pacific regions, putting over 3 billion people at risk of infection. In most temperate areas of Asia, JEV is transmitted mainly during the warm season, when large epidemics can occur. In the tropics and subtropics, transmission can occur year-round but often intensifies during the rainy season and pre-harvest period in rice-cultivating regions (Figure 4.2).

Japanese encephalitis has a high mortality rate and is a leading cause of acute encephalitis syndrome (AES) often with long term neurological sequelae [3]. While most infections caused by the JEV result in mild symptoms like fever and headaches or show no apparent signs, approximately one in 250 infections lead to severe clinical illness. The incubation period typically ranges from 4 to 14 days. In children, initial symptoms may manifest as gastrointestinal pain and vomiting. Severe disease is characterized by a sudden onset of high fever, intense headache, stiffness in the neck, confusion, coma, seizures, spastic paralysis, and, in the worst cases, death. Only about 1% of JEV infections progress to clinical disease, most often manifesting as encephalitis. Among cases of JE attributable AES, the case fatality rate (CFR) can be as high as 30%, and long-term neurological or physical sequelae occur in 30 to 50% of survivors such as paralysis, recurrent seizures, or even the loss of speech. Approximately 75% of JE cases occur in children aged under 15 years. There is no cure for JE, and treatment is largely supportive to relieve symptoms providing support to help patients recover from the infection [1, 4].

Understanding JE is crucial due to its significant public health impact, especially in the regions where it is endemic.

4.8 The public health importance of Japanese Encephalitis in Vietnam and in Son La Province

In Vietnam, JE is a prominent concern due to it's potential to cause severe neurological complications and even death. JE disease was first reported in Vietnam in 1952 and the JEV was first isolated in 1964 at NIHE. The disease has been endemic throughout the country, most in the northern delta and midland provinces since then. Outbreaks have mostly been concentrated in wet-rice growing areas or semi-mountainous areas.

In Vietnam, viral encephalitis has been reported in the Infectious Diseases Surveillance System for many years and has been systematically reported since the nationwide establishment of the EPI program in 1985. The National Electronic Diseases Surveillance System (NEDSS) was introduced later and implemented nationwide in 2016. The sentinel surveillance system has recorded thousands of viral encephalitis cases annually, among which, JE is one of the main causes of acute central neutral system infection. JE disease is vaccine preventable and a vaccine has been available since 1997 (the inactivated mouse brain–derived JE vaccine (JEVAX) used is manufactured in Vietnam). Before the JE vaccine introduction, there were about 2000-3000 cases of the JE disease every year. Since introduction of JE vaccine under the national expanded program on Immunization (NEPI), the number of cases and deaths from JE disease has decreased significantly. Between 2010 and 2022 an average about 250 new JE cases were reported each year among all age groups [5-7] (Figure 4.3).

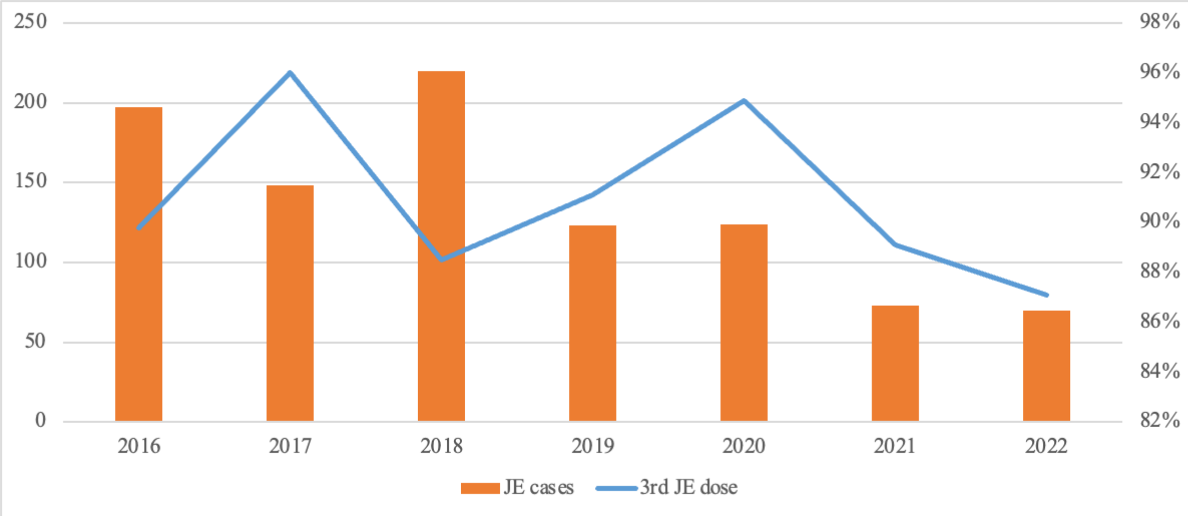

Figure 4.3. JE case per year and JE vaccine coverage in 28 northern provinces in Vietnam, 2016-2022.

The vaccination efforts, surveillance strategies, and comprehensive public health measures implemented to mitigate the spread of the disease reflect the seriousness with which Vietnamese authorities approach Japanese Encephalitis. Vietnam is divided into four regions for JE disease surveillance (northern (28 provinces), central (11), highlands (4), and southern (20). Since 2010, the JE sentinel surveillance has been gradually expanded nationwide after pilot implementation in some provinces since 2005. Currently, Vietnam has eight JE sentinel sites (northern (3 sites), central (2), highlands (1), and southern (2) [8]. Son La is one sentinel site out of three sites in the Northern Vietnam, operated in 2016 in parallel with the general infectious disease surveillance system. Son La was selected as the research site as there is a valuable source of data from the JE sentinel surveillance system for comparison. Besides sentinel surveillance, two national laboratories in NIHE in Hanoi and Pasteur Institute in Ho Chi Minh city have responsible for confirmation testing from provincial CDCs in line with WHO JE lab net system. In Vietnam, while JE surveillance is predominantly managed by the health sector, there is emerging intersectoral collaboration with the Ministry of Agriculture and Rural Development, aligned with the One Health approach. This includes entomological monitoring of mosquito vectors and JE sero-surveillance in pigs, which serve as amplifying hosts.

Son La is a province in the Northwest region of Vietnam, it shares a border with Laos to the south. Son La province has approximately 1.2 million residents, with the Thai ethnic group comprising the largest portion of the population at approximately 53.2%. Following by the Kinh group accounts for about 17.61%, the H'mong group makes up approximately 14.61%, the Muong group represents around 7.57%, the Xinh Mun group constitutes about 1.98%, and the Dao group comprises approximately 1.77%. The other ethnic minority groups account for a very small proportion, less than 1% (Ethnic Minority census 2017) [9] (Figure 4.4). The area is agricultural production land where the majority of crops are wet rice and other tropical crops. It is also and areas where popular household practice of pig raising has created suitable conditions for the circulation of JEV in natural environment, thereby leading to the transmission of JE disease in humans. The local public health importance of Japanese Encephalitis cannot be overstated.

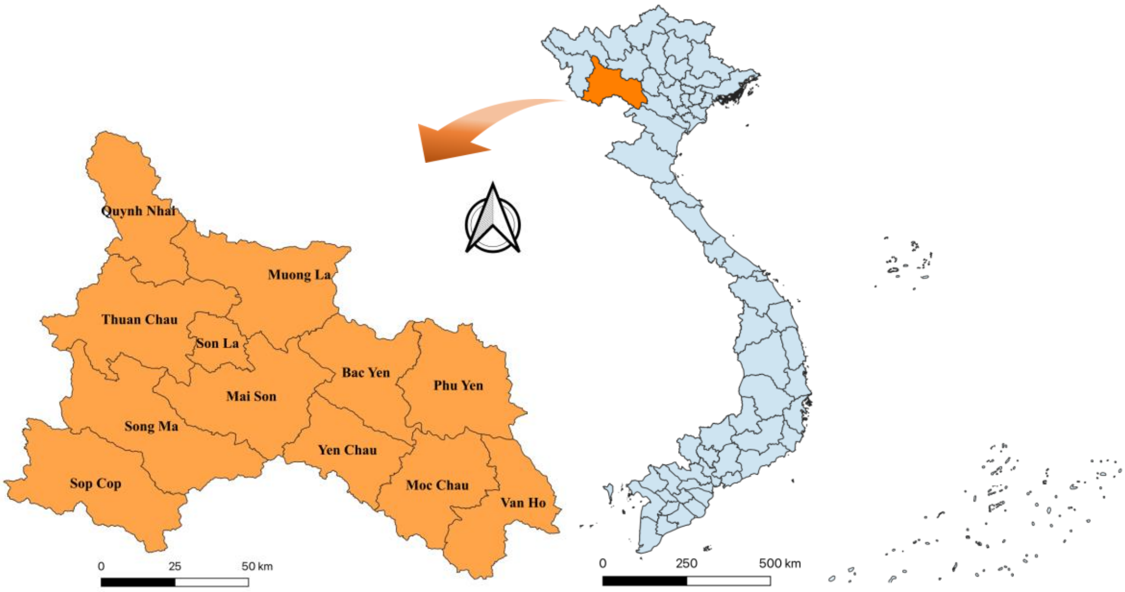

Figure 4.4. Geographical map of Son La province in Vietnam.

National target for JE vaccine coverage is reaching over 90% coverage of three doses of Japanese encephalitis vaccine for children 2-5 years of age [5]. Currently JEVAX regimen of NEPI in Vietnam is 3 doses for children aged 1 to 5 years: 1st dose is administered at 12 months, 2nd dose is administered + 2 weeks after the 1st dose, 3rd dose is administered at 2 years).

To date, a single study has documented the 10-year-long national surveillance for Japanese encephalitis in Vietnam from 1998 to 2007 [10], focusing more on epidemiological findings rather than a comprehensive evaluation of the attributes of the previous infectious disease surveillance system.

4.9 Evaluation Framework

4.9.1 Objectives of the evaluation

We evaluated the Japanese Encephlatis indicator-based surveillance system at Son La province, Vietnam over the period of seven years from 2016-2022, by using JE case surveillance report data extracted from National Electronic Disease Surveillance System (NEDSS) for Son La Province and data reported from JE sentinel surveillance system in Son La province; reviewing JE-related doccuments and interviewing stakeholders.

Objectives

Undertake an evaluation of the surveillance of JE in Son La province:

- *To assess the strengths and weaknesses of the Japanese Encephalitis (JE) sentinel surveillance system in Son La province, Vietnam, by evaluating four attributes—simplicity, data quality, flexibility, and sensitivity—based on the US CDC guidelines* [11].

4.9.2 System Description

At the time of evaluation, two surveillance systems for JE were being implemented concurrently in Vietnam, summarized as follows:

Sentinel surveillance system: implemented in a limited number of designated hospitals. All suspected JE cases identified at these sites are sampled and tested at the NIHE laboratory. This system therefore captures the total number of suspected JE cases under surveillance, with laboratory results available for both positive and negative cases.

NEDSS: implemented across all health facilities nationwide. Data entry typically occurs in three steps: (1) initial entry of suspected cases based on clinical diagnosis, which serves as an early warning signal (with or without sample collection); (2) additional entry when samples are collected; and (3) entry of laboratory results. Cases testing negative are removed from the database, so the final NEDSS dataset includes suspected cases awaiting results, clinically suspected cases not sampled, and confirmed positives.

All laboratory testing for JE is centralized at the NIHE laboratory.

To describe the NEDSS, I gathered information from the Vietnam Government Department of Health (Ministry of Health) website and official documents, NEDSS annual reports, and engaged in face-to-face consultations with the epidemiologist in charge of Vaccine Preventable Diseases Surveillance (VPDS), as well as with NEDSS data managers at the Northern EPI office within the NIHE.

4.9.3 Evaluation of the system attributes

This evaluation focused on four key attributes - simplicity, data quality, flexibility, and sensitivity - based on their relevance to the current performance and context of JE surveillance in Son La province. These attributes were selected in accordance with US CDC guidelines, which recommend focusing on the attributes most pertinent to the system's objectives and the available data. Simplicity and flexibility reflect how practical and adaptable the system is in real-world settings, while data quality and sensitivity directly influence the accuracy of case detection and the effectiveness of the response. Other attributes, such as timeliness or representativeness, were not prioritized due to limitations in data availability and feasibility. Attributes of the NEDSS for JE surveillance were defined and evaluated as follows:

Simplicity

To gauge how easy this surveillance system is to understand and use, we examined how data moves through the system, including reporting levels, reporting structure, and data handling. This assessment relied on system documentation and input from Son La Provincial General Hospital personnel.

Data quality

To evaluate the completeness and accuracy of JE notifications in the NEDSS, we examined the completeness and logic of crucial variables such as vaccination status, epidemiological history, onset date, sampling date, testing result date, current status (treatment outcomes for inpatients), and dates of hospital discharge, referrals, or fatalities. Additionally, we also compared quantitative data with feedback from hospital staff and CDC staff.

Flexibility

This assessment focuses on the system's capacity to effectively adapt to changing conditions and needs, including the impact of events such as the COVID-19 pandemic. It evaluates how well the system can swiftly adjust its operations, protocols, and data collection methods to address new challenges and requirements. The goal is to ensure that the system remains responsive and effective, even in the face of unforeseen circumstances like a pandemic.

Sensitivity

To determine the ability for the NEDSS to capture JE case in the community, measured by the NEDSS's ability to:

- **Case detection:** The proportion of laboratory-confirmed JE cases reported through NEDSS (x) compared with the total number of laboratory-confirmed JE cases in the entire population of Son La (y). The total number of positive JE cases in the province was calculated by combining cases reported through the NEDSS and the JE sentinel surveillance system, then subtracting any duplicate cases identified in both systems. Sensitivity was calculated as:

$$\text{Sensitivity} = \frac{\text{Number of laboratory-confirmed JE cases reported via NEDSS in Son La (x)}}{\text{Total number of laboratory-confirmed JE cases in Son La (y)}} \times 100\%$$

- **Outbreak detection**: assessing the NEDSS's ability to detect JE outbreaks occurring in the community.

The JE sentinel surveillance system, implemented in a limited number of designated hospitals, monitors all suspected JE cases and ensures 100% sample collection with laboratory confirmation (positive or negative), using more detailed case investigation forms to provide comprehensive clinical and epidemiological data. In contrast, NEDSS functions as a nationwide early warning system, where suspected cases are initially reported based on clinical diagnosis, but not all are sampled, and laboratory-negative cases are removed from the database, resulting in differences in case capture and sensitivity between the two systems.

4.9.4 Data collection

For the purpose of quantitative analysis, we extracted the data of all Japanese Encephalitis (JE) cases reported and recorded in the NEDSS of Son La province from January 1, 2016, to December 31, 2022, into a Microsoft Excel file for analysis.

For the qualitative aspect, we developed an in-depth interview guideline based on the Vietnamese government's regulations for operating notifiable disease surveillance systems [12] and the guidelines from the US CDC on evaluating specified attributes of disease surveillance systems [11].

The interviews were carried out face-to-face, and the interviewees provided verbal consent. Utilizing the interview questionnaire (refer to Appendix 4.3), participants were prompted to elucidate their roles within the JE surveillance system, share their perspectives on the designated attributes of this system, and offer recommendations.

4.9.5 Engagement with key stakeholders

The key stakeholders for the surveillance of JE were identified with the assistance of the NIHE, totalling 15 individuals. I conducted consultations with members of the NEDSS and JE surveillance system at NIHE, the Son La CDC and the Son La general hospital (Appendix 4.1).

4.9.5.1 NEDSS – Northern JE Surveillance managers

JE surveillance in the Northern region of Vietnam is an activity managed by the Northern EPI office, as this is a vaccine preventable disease under control by the expanded immunization program. Members include JE epidemiologists from the NIHE, monitoring officers, authorized testing personnel, as well as coordinators and surveillance system managers. The members of this surveillance program routinely utilize NEDSS data in conjunction with sentinel JE surveillance data to assess the JE disease activities in Northern Vietnam. These members were contacted and interviewed between April 10-14, 2023.

4.9.5.2 Son La CDC epidemiologist and NEDSS data managers

JE surveillance at the Son La CDC is also an activity managed by the provincial EPI unit, the Department of Infectious Disease Control. Members include epidemiologists, monitoring officers, authorized testing personnel (specimen preservation and transportation), as well as coordinators and managers of the province's overall JE surveillance system. The role of the data manager at Son La CDC involves monitoring data entry progress, storage, maintenance, and updating of testing information. These members of the surveillance initiative regularly utilize NEDSS data in conjunction with sentinel JE surveillance data to assess the JE disease activities within Son La province. These members have been contacted and directly interviewed from April 19-20, 2023.

4.9.5.3 Son La general hospital – healthcare workers and NEDSS data managers

At the Son La General Hospital, participation in JE surveillance involves:

- Clinical staff from pediatrics and infectious disease departments, including doctors and nurses who perform diagnoses, complete investigation forms, and collect specimen samples.
- Testing personnel responsible for preserving samples at the hospital while awaiting transfer to Son La CDC staff.
- Planning department personnel who manage data and report case information on the NEDSS system.

These members have been contacted and directly interviewed from April 19-20, 2023.

4.9.6 Data analysis

Employing Microsoft Excel, we performed descriptive analyses to evaluate the quality of surveillance data extracted from the surveillance system. Demographic data were collected for age, gender, occupation and ethnicity. In addition data were extracted on JE infection, vaccination status and clinical outcome.

To examine the system's functioning, we combined relevant information sourced from official government documents, official reports, as well as insights gathered from the interviewees. Interview transcripts were manually transcribed into Microsoft Word and organized based on the following attributes of the system: Simplicity, Data Quality, Flexibility, and Sensitivity.

Qualitative data analysis: Handwritten interview notes were reviewed and coded manually according to key thematic groups, followed by thematic content analysis. Relevant quotes were selected to illustrate key findings.

4.10 Ethics approval

Ethics review of this evaluation was waived by the Australian National University Human Research Ethics Committee under the protocol number 2017/909.

Ethical approval from Vietnam was not required because JE surveillance is routine surveillance carried out under the supervision of NIHE.

4.11 Results

4.11.1 Analysis of confirmed JE notifications in the NEDSS, 2016-2022

There were 83 notifications (75 confirmed cases and 8 suspected cases) reported on the NEDSS in Son La province from 2016 to 2022.

Figure 4.5 illustrates the distribution of JE cases by month over the years, with the majority of cases recorded in 2017 and 2018; 24 (29%) and 33 (40%) cases respectively. The lowest number of cases occurred in 2019, with only 2 cases. The months with the highest occurrence of cases span from June to August each year, accounting for 73 cases, or 88% of the total.

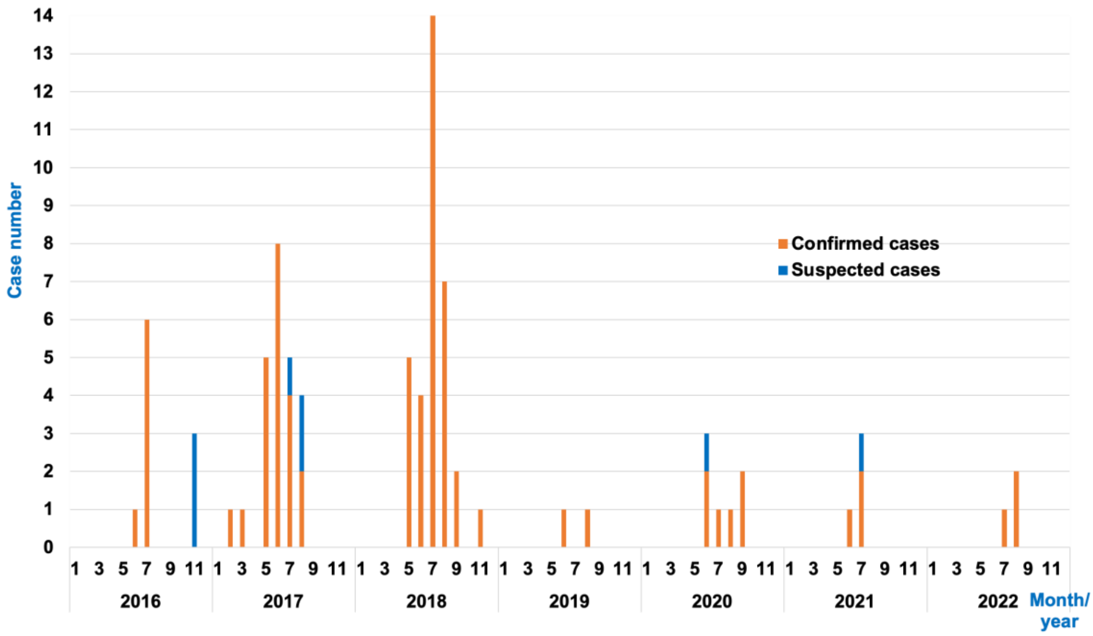

Figure 4.5. JE notifications, by month and year, Son La province, Vietnam 2016-2022

All 12 districts, including 1 city (Son La city) and 11 districts of Son La province, reported cases throughout the assessment period. The district with the lowest number of cases recorded 3 cases, while the district with the highest number reported 9 cases (Figure 4.6).

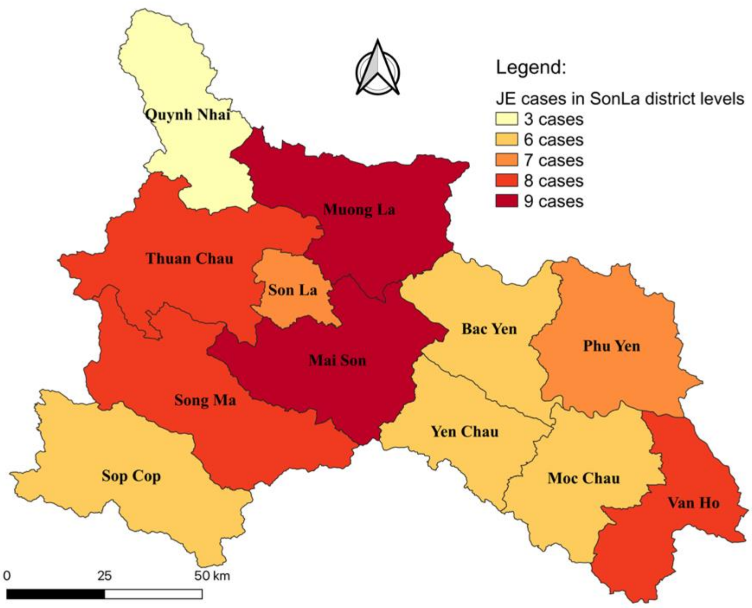

Figure 4.6. JE notifications by residential locations, Son La province, Vietnam 2016-2022

Table 4.1 shows that the average age of JE cases was 26 years (interquartile range ranging 11 to 40 years). Children under 1 year old and school-age children (5-18 years old) constituted the majority of cases, accounting for 13% and 47% respectively. The adult group comprised 23% of cases. There was a significant gender disparity, with 64% of cases occurring in males. The primary noteworthy occupation is that nearly 23% are farmers, excluding the group of children either attending school, not attending, or below school age. The Thai ethnic group accounted for the highest proportion at 51.8%, followed by the Mong ethnic group at 26.5%. Only 4.8% (4 cases) had received at least one dose of JE vaccination, while a substantial 48.2% were not vaccinated, and 47% had no vaccination history available. There were eight deaths reported at the time of the report, accounting for 9.6% of the total cases.

Table 4.1. *Notifications of laboratory-confirmed JE in Son La province, 2016-2022, by age group and year and vaccine coverage*

	Cases (n=83)	Percentage (%)
Age (median, IQR)	**26 (11-40)**	
Age group		
<1y	**11**	**13%**
1- <2y	1	1%
2- <5y	13	16%
5 - <18y	**39**	**47%**
>=18y	19	23%
Gender		
Male	**53**	**64%**
Female	30	36%
Occupation		
Preschool children/not attending school	**33**	**39.8%**
Students	**28**	**33.7%**
Farmers	**19**	**22.9%**
Workers	1	1.2%
Others	2	2.4%
Ethnicity		
Dao	1	1.2%
Kinh	7	8.4%
Mong	**22**	**26.5%**
Muong	8	9.6%
Thai	**43**	**51.8%**
Xinh mun	2	2.4%
JE vaccine status (≥ 1 dose)		
Yes	**4**	**4.8%**
No	40	48.2%
Unknown	39	47%
Outcomes		
Cases survived	75	90.4%
Deaths	**8**	**9.6%**

4.11.2 System description – National Electronic Diseases Surveillance System (NEDSS)

4.11.2.1 NEDSS history and scope

The Vietnam NEDSS is a comprehensive digital platform designed to effectively monitor and manage infectious diseases across the country (Figure 4.7). The system was developed and piloted in several provinces in 2012, after which it was fully implemented nationwide in 2016. NEDSS serves as a central hub for collecting, analyzing, and disseminating timely and accurate disease-related information. Its key components include data entry, integration, analysis, and reporting functionalities, enabling a seamless flow of disease-related data between various levels of the healthcare system.

NEDSS plays a pivotal role in disease surveillance by facilitating rapid data capture from healthcare facilities, and other reporting entities. The system allows authorized personnel to input detailed case information, including demographics, clinical symptoms, laboratory test results, and geographical location. This data is then systematically organized, aggregated, and analyzed, enabling health authorities to detect and respond to disease outbreaks promptly.

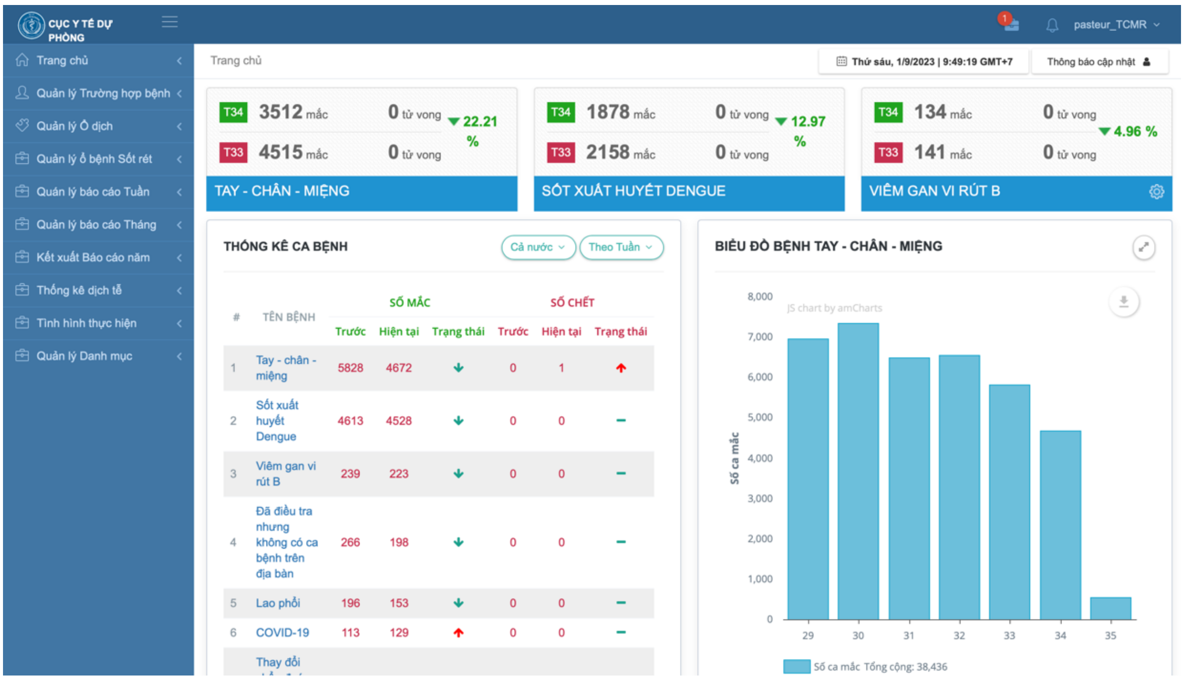

Figure 4.7. Screenshot of NEDSS dashboard

(Source: https://baocaobtn.vncdc.gov.vn/Home/Index)

4.11.2.2 National surveillance of JE in Vietnam and in Son La province

The Ministry of Health classifies JE as a Group B infectious disease under the Law on Prevention and Control of Infectious Diseases. Group B diseases are considered dangerous and require immediate report individual case within 48 hours of detection [12]. JE is one of the 42 infectious diseases listed for reporting in the NEDSS. The JE surveillance activities are generally similar to those of other infectious diseases, following the operational procedures of the NEDSS system. However, JE has a notable difference compared to many other diseases in that it is supported by a sentinel surveillance system, as mentioned above. Son La is one of the three northern region provinces implementing sentinel JE surveillance. In Son La province, JE surveillance is an integration of both general surveillance and sentinel surveillance.

The objectives of Japanese Encephalitis (JE) surveillance in Vietnam include:

- *Early Detection and Diagnosis:* To promptly identify and diagnose JE cases, allowing for timely treatment and response to prevent further spread.
- *Monitoring Disease Trends:* To track the occurrence and distribution of JE cases over time, enabling health authorities to identify trends and patterns.
- *Assessing Impact:* To evaluate the impact of JE on public health, including morbidity, mortality, and the effectiveness of vaccination programs.
- *Epidemic Preparedness and Response:* To enhance the capacity to respond effectively to JE outbreaks by mobilizing resources and implementing control measures.
- *Data-Informed Decision-Making:* To provide data for evidence-based decision-making, enabling health authorities to allocate resources efficiently and implement targeted interventions.

4.11.2.3 National surveillance case definition for JE

According to **the guidelines from Vietnam's Ministry of Health** [13], the definitions of Japanese Encephlatis cases are as follows:

a. Suspected cases:

- Cases showing symptoms of acute encephalitis-meningitis, characterized by sudden high fever accompanied by headache, nausea, vomiting, neck stiffness, possible seizures, paralysis, and altered consciousness (stunned state, disorientation, absent-mindedness, unconsciousness); or
- Cases showing symptoms of acute encephalitis-meningitis, with the following manifestations:

+ High fever of 38-40°C accompanied by headache, nausea, vomiting, seizures, and neck stiffness.
+ Possible altered consciousness, paralysis, stunned state, disorientation, abnormal movements (tremors, convulsions), unconsciousness, slow or incomprehensible speech, rigid paralysis.
+ Excessive accumulation of phlegm.

b. Confirmed cases:

These are cases that were initially suspected based on the criteria mentioned earlier. Confirmation is achieved when the test results indicate the presence of positive IgM antibodies or when a specific viral gene segment is identified using molecular biological techniques.

According to **the Sentinel JE surveillance system instructed by National EPI, NIHE** [8], the classification of Japanese Encephlatis cases are as follows:

- *Case classification*:

  Suspected JE cases as defined above will be diagnosed or ruled out based on the following criteria (Figure 4.8):

  + **Confirmed JE diagnosis:** A suspected JE case with cerebrospinal fluid and/or serum specimens collected as required, having a positive IgM diagnosis using the MAC-ELISA method.
  + **Not JE case:** A suspected JE case with cerebrospinal fluid and/or serum specimens collected as required, having a negative IgM diagnosis using the MAC-ELISA method.
  + **Uncertain:** A suspected JE case without collected cerebrospinal fluid or serum specimens, or when the collected specimens do not meet the required standards, or when the IgM test results are unclear.

Note: In addition to the MAC-ELISA method for IgM detection, there are also many other diagnostic methods such as isolating the JE virus from cerebrospinal fluid or serum, PCR detecting JE virus genes, detecting IgG antibodies (in this case, a fourfold or higher increase in specific antibodies against JE virus in serum during the recovery phase compared to the acute phase).

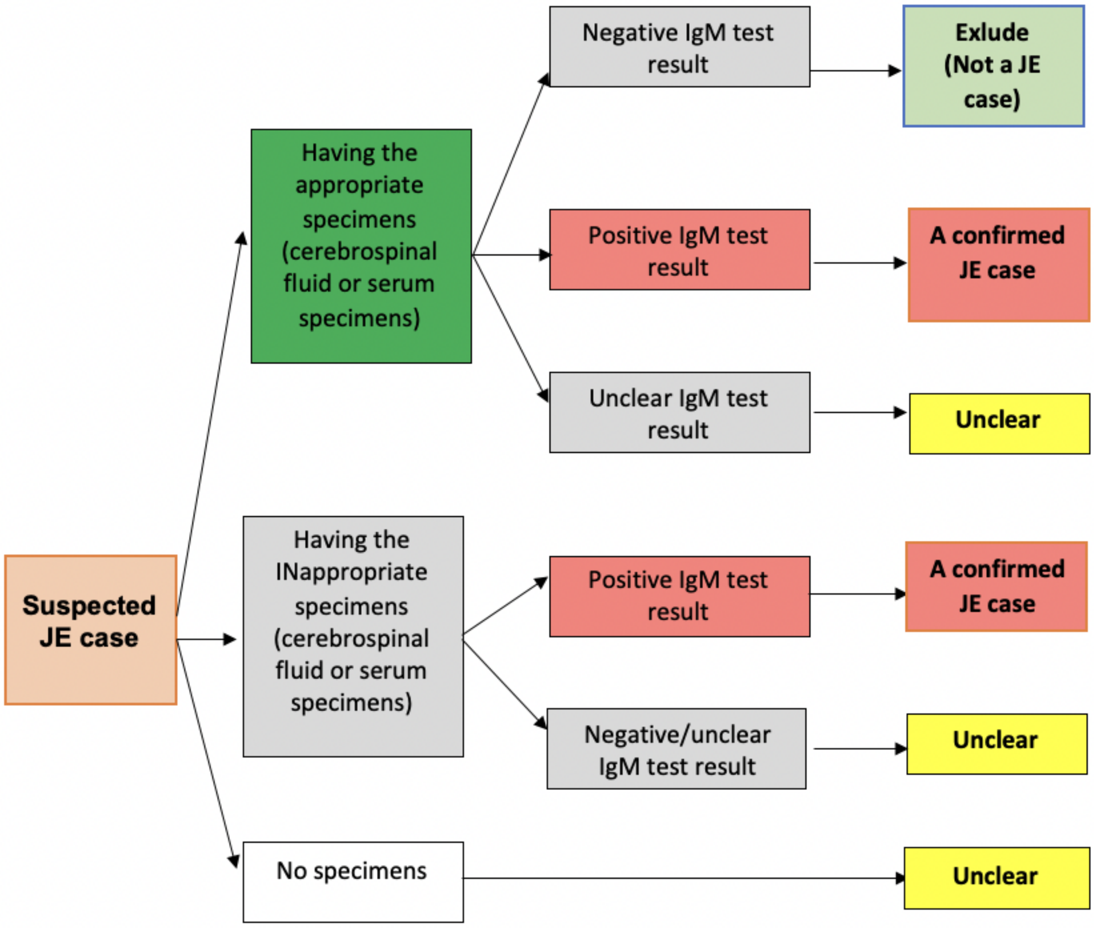

Figure 4.8. Japanese Encephalitis Diagnostic Flowchart, Vietnam

(Inappropriate specimens refer to CSF or serum samples that did not meet the criteria for JE testing (e.g., inadequate volume, poor storage, or incorrect timing of sample collection)).

- *Surveillance Guidelines:*
  - Cases are investigated using the *"Japanese Encephalitis Case Investigation Form"* (Appendix 4.2).
  - Specimen Collection:
    + Ideally, collect cerebrospinal fluid (1ml). If cerebrospinal fluid cannot be collected, then collect serum blood (1ml).
    + Specimen collection should ideally start from the 3rd day after the onset of the disease.

Note: Serum samples collected upon admission may not yield positive results for JE. A second sample collection upon discharge or on the 10th day after the disease onset is recommended.

- *The indicators for evaluating the quality of the JE surveillance system*

Indicators for evaluating the quality of the JE surveillance system in Table 4.2 are implemented under the supervision of the EPI program, particularly applied for JE sentinel surveillance provinces.

Table 4.2. *The indicators for evaluating the quality of the JE surveillance system*

Indicators	Target
1. Proportion of complete monthly reports*.	≥ 90%
2. Proportion of timely monthly reports.	≥ 80%
3. Proportion of suspected JE cases investigated according to the standard protocol.	≥ 90%
4. Proportion of suspected JE cases with cerebrospinal fluid samples taken.	≥ 80%
5. Proportion of cerebrospinal fluid and blood samples sent to the reference laboratory according to regulations.	≥ 80%
6. Proportion of specimens with test results within 1 month.	≥ 80%
7. Proportion of blood samples collected at least 10 days after the onset of illness.	≥ 80%

**Reports: Number of JE cases/deaths in the infectious disease report under the EPI program.*

4.11.2.4 Data reporting management

Each authorized healthcare facility at all levels of government management, including private healthcare systems, is provided with a separate account to access the system for reporting, modifying, and updating disease information (Figure 4.9). Consequently, each unit will assign an account management team to manage the data and input information about JE cases into the system. Depending on the scope of their management, these accounts may access data at the corresponding level. Data entry typically occurs in three steps: (1) initial entry of suspected cases based on clinical diagnosis, which serves as an early warning signal (with or without sample collection); (2) additional entry when samples are collected; and (3) entry of laboratory results. Cases testing negative are removed from the database, so the final NEDSS dataset includes suspected cases awaiting results, clinically suspected cases not sampled, and confirmed positives.

All laboratory testing for JE is centralized at the NIHE laboratory. The average turnaround time for laboratory results, from sample collection to reporting, was about two weeks.

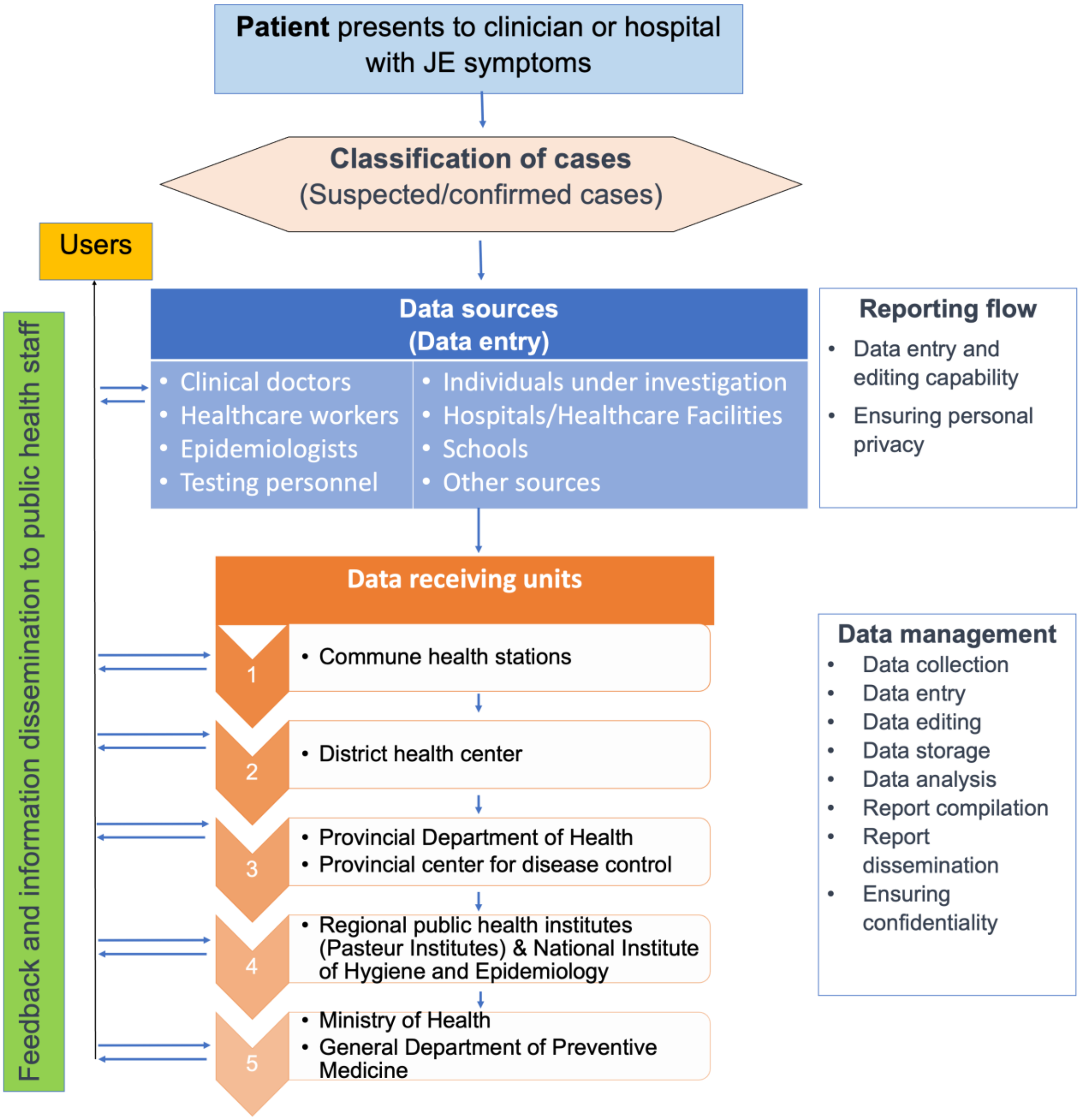

Figure 4.9. Data flow of JE notifications in to the NEDSS, Vietnam

In the case of Son La province, data entry, information updates, and automatic data transmission through the NEDSS system occur daily and with a high level of reliability. Data managers at the provincial CDC have reported that data runs regularly and disruptions are rare.

All data managers interviewed noted that the technical specifications on NEDSS are clearly explained for each field and field type (date, text, number), indicating whether they are mandatory or not. One data manager suggested that the history of changes to the specifications should be provided to enable jurisdictions to review their systems and contact the appropriate channels when they need to verify information.

4.11.3 System performance

4.11.3.1 Simplicity

The use of NEDSS for reporting, editing, updating information, and receiving reports, as well as providing feedback, is relatively straightforward for both data managers and monitoring officers. However, using the NEDSS system sometimes encounters errors, but there is no specific point of contact to report them and address them promptly.

Variables in the reporting system

Table 4.3. lists all the variables present in the NEDSS when documenting a case of JE. These variables fall into three primary categories: patient demographics, the patient's diagnosis information, and reporter information.

In a case report form, there are 16 mandatory input variables and 16 fields that are optional.

Table 4.3. *All variables of JE in the NEDSS*

Patient demographics	Diagnosis information	Reporter information
Mandatory input variables		
1. Full name 2. Date of birth 3. Occupation 4. Ethnicity 5. Sex 6. National ID 7. Phone number 8. Current residential address	1. Date of health check/hospitalization 2. Sample collecting status (If yes) 2.1. Testing name 2.2. Date of sampling 3. Vaccination status (If yes) - Number of vaccine doses 4. Number of vaccine doses	1. Reporter's full name 2. Reporter's phone number 3. Reporting workplace 4. Treatment facility
Optional input variables		
9. Workplace 10. Permanent living address	5. Classification of disease severity 6. Current situation 7. Date of onset 8. Date of hospital discharge/referral/death 9. Diagnostic classification 10. Test classification 11. Testing unit 12. Testing result	5. Reporter's email

Patient demographics	Diagnosis information	Reporter information
	13. Date of testing result 14. Diagnosis of comorbidities 15. Diagnosis of complications 16. Epidemiological history 17. Note for other details	

During the on-site discussion regarding the simplicity of the NEDSS surveillance system, including JE, all 100% of the interviewed individuals stated that the surveillance process, collaboration between different levels, and coordination between Preventive Medicine and Clinical Health (hospitals) were closely-knit and flexible. The use of the investigation form (Appendix 4.2) was found to be very convenient, simple, and easy to understand. Reporting criteria were easy to follow. However, stakeholders provided feedback on collecting data via **the JE reporting form highlighted some of the operational and reporting issues that they encounter**:

> *"Regarding the **treatment outcome** variable at the hospital, it is often challenging to determine the ultimate outcome of patients due to specific cultural factors. Here, the families of patients often request to take them home for care (as they fear death outside their place of residence) when doctors predict a "very severe and low chance of recovery" condition" (Medical doctor). Epidemiologists from the provincial CDC agreed on this issue and provided additional information that this was a challenging variable to obtain information on, despite the efforts of local healthcare authorities to update patient outcomes related to JE. One provided additional feedback: "Information about the **complications and sequelae** of the disease is also challenging to report in the system, making it difficult to assess the disease burden of JE". (epidemiologist, CDC Son La)*

Regarding the operation of NEDSS, some factors related to infrastructure and equipment have also been mentioned in the interviews:

> *"In the last two years, NEDSS has encountered several issues related **to internet connectivity, data extraction problems**, and the system appears to have not been upgraded, resulting in relatively slow operations" (data manager, CDC Son La).*

> *"The input of disease case information into the NEDSS is still carried out under conditions where there is a lack of dedicated computers for infectious disease surveillance activities, which can lead to delays in reporting time." (data manager, Son La general hospital).*

*While conducting JE surveillance through NEDSS is considered straightforward, there are still suggestions from 60% of respondents regarding access to instructional materials and training. A comprehensive opinion from an epidemiologist at CDC Son La states: "Regarding the use of NEDSS for reporting and updating information, there are significant **limitations in terms of instructional documents and guidance** for using the electronic reporting system. There is **a lack of training** from the higher levels, with only provincial-level training conducted in the past five years, meaning that provincial-level staff provided training to district-level staff. This has posed challenges for the province, especially considering the relatively high turnover of personnel during this time".*

4.11.3.2 Data quality

The evaluation of JE surveillance data quality through NEDSS includes: 1) Evaluating data validity, which determines the extent to which the data reflect the truth or, in other words, estimates the proportion of erroneous data; 2) Assessing completeness, which involves examining the level of completeness of key variables or, in other words, the proportion of missing data.

Data sources for evaluation come from the NEDSS system and investigation forms (see sample form in Appendix 4.2).

4.11.3.2.1 Data Validity

Figure 4.10. below shows that the total number of cases with positive JE test results was 75 cases; however, when **classified**, only 54 cases are laboratory-confirmed. There was a discrepancy of 21 cases (28%) that do not match between test results and diagnostic classification, occurring over 5 out of the 7 years of evaluation. Specifically, 2017 had the highest discrepancy with 11 cases (52.4%), followed by 4 cases in 2018 (12.1%), 3 cases in 2022 (100%), 2 cases in 2020 (33.3%), and 1 case in 2021 (333%).

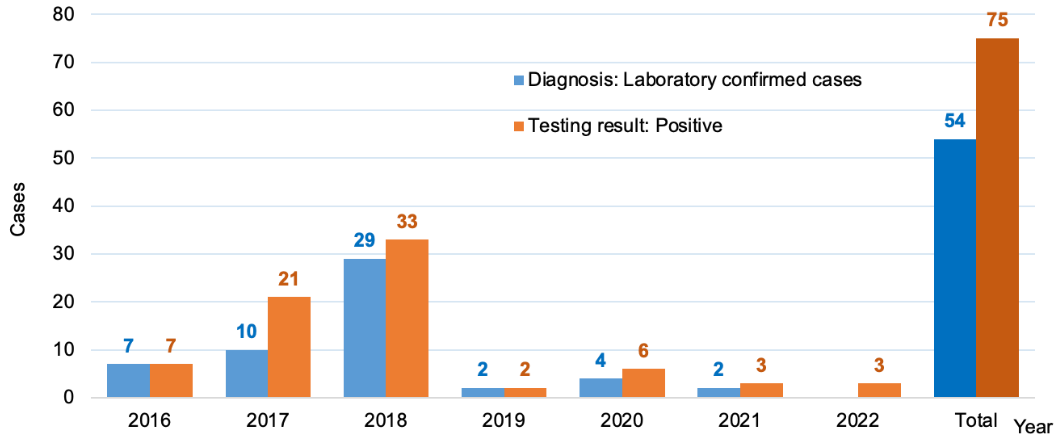

Figure 4.10. Comparing the number of JE cases diagnosed as laboratory-confirmed cases and test results.

The 21 discrepant cases occurred because their “Diagnostic classification” had already been entered as “laboratory confirmed case”, but the variable “Testing result” field was not updated to “positive” after NIHE results were received, and instead remained at the provisional clinical classification. The explanation for this discrepancy provided by local personnel was:

> *“Because the test results from NIHE were sent to the Son La CDC at a later time (not simultaneously with the initial data entry), updating the information regarding test results and the final diagnosis may be overlooked.” (data manager, Son La CDC).*

4.11.3.2.2 Data completeness

Data from the NEDSS reveals that information about the vaccination status for JE was only recorded for 44 cases (53%), meaning that 47% had unclear or missing information. This was highest in 2018 and 2020 with rates of 45.5% and 42.9%, respectively. The date of sample collection was recorded for only 71.4% of cases in 2016, resulting in an overall data completeness of 97.3% in this time frame. Other mandatory input variables were also often ignored, with the testing facility variable omitted in 100% of cases. Only 3.6% of cases included recording of national ID card information, and nearly 16% of patients lacked contact phone numbers.

Non-mandatory variables were often entirely overlooked, such as "workplace of patients" and "Classification of Disease severity." The "Epidemiology history" variable was only recorded for 2.4% (2 cases), and the responses were limited to summarizing symptoms and treatment processes, with epidemiological information absent. The data were also incomplete for listing the reporting person, notably in terms of phone numbers (4.8%) and an absence of a contact email address (67.5%). (Table 4.4).

An issue reported during the interviews was presence missing information on JEvaccination status and the difficulty in locating this in the records. One stakeholder commented:

> *"For patients' **vaccine JE status**, we encountered difficulties in retrieving it because patients admitted for treatment often do not carry vaccination records. The primary source of information is usually obtained from the statements of parents or caregivers, who often do not remember or provide accurate information, leading to lower reliability. This has been verified and updated by local health workers at the commune level, but there are still many gaps." (epidemiologist, CDC Son La).*

Table 4.4. *Specific variables for data completeness concerns (n=83)*

No.	Variable	2016 n (%)	2017 n (%)	2018 n (%)	2019 n (%)	2020 n (%)	2021 n (%)	2022 n (%)	Total n (%)
1.	***Vaccination status****	7 (70%)	12 (50%)	**15 (45.5%)**	1 (50%)	**3 (42.9%)**	3 (75.0%)	3 (100%)	**44 (53%)**
2.	***Date of sampling**** [*,a]	**5 (71.4%)**	21 (100%)	33 (100%)	2 (100%)	6 (100%)	3 (100%)	**3 (100%)**	**73 (97.3%)**
3.	***National Identification Card****								**3 (3.6%)**
4.	***Phone number of patients****								**70 (84.3%)**
5.	***Testing facility*** [*,a]								**0**
6.	***Reporter's phone number****								79 (95.2%)
7.	*Workplace of patients*								**0**
8.	*Classification of Disease Severity*								**0**
9.	*Epidemiological history*								**2 (2.4%)**
10.	*Reporter's email*								**27 (32.5%)**

*mandatory input variables

[a] n=75

4.11.3.3 Flexibility

The NEDSS is a relatively flexible electronic reporting system, allowing for the addition, deletion, and modification of data fields within the scope of authorized management.

The data sources for JE surveillance in Son La are expanding. In 2016, JE monitoring was initially implemented as a sentinel surveillance site only in one hospital (Son La Provincial General Hospital). However, active surveillance was extended to the entire province starting in 2018. In this context, “active surveillance” refers to proactive case-finding activities conducted by Son La CDC staff, who made regular monthly or ad-hoc supervisory visits to hospitals across the province to assess JE surveillance and reporting, and to identify any suspected cases that might have been missed for reporting into NEDSS. This approach served to support and strengthen NEDSS rather than to replace or integrate with it. There was a relocation of Son La Provincial General Hospital in 2020, which increased the distance between it and Son La CDC from approximately 2 km to about 10 km. Nevertheless, surveillance and sample collection continue to be carried out effectively.

The COVID-19 pandemic since 2020, lead to a reorganization of personnel to prioritize its response. In general, the incidence of other infectious diseases has decreased, and vaccine coverage has also decreased in terms of data reported. The local JE surveillance system has been integrated with general infectious disease monitoring and COVID-19 monitoring. Despite these changes, the JE surveillance system continues to function according to its purpose.

Some other changes have been noted by local surveillance personnel: "*The case investigation form changed once, but we have maintained our surveillance procedures without any difficulties. However, the personnel at the commune and district levels often change and do not receive adequate and timely training, especially during the COVID-19 period. This has caused interruptions in surveillance at certain times or has resulted in an overload of work for many officers who have to take on additional responsibilities." (epidemiologist, CDC Son La).*

4.11.3.4 Sensitivity

The evaluation of JE surveillance sensitivity through NEDSS includes: 1) Assessing the ratio (x/y) between the reported positive JE cases in Son La province on the NEDSS system (x) and the total number of positive JE cases in the community of Son La province (y). 2) Evaluating the detection of JE outbreaks in the community through the NEDS system.

4.11.3.4.1 The ratio of positive JE cases in the NEDSS system compared to the positive cases in the community.

The sensitivity of the NEDSS was low, detecting only 83 out of 112 cases, a 74.1% of cases (Table 4.5). The number of JE cases reported in Son La province within the NEDSS is consistently lower than the actual number of JE cases known in the community for the majorityof the evaluation period. In 2021 only 4 cases were reported in the NEDSS system, however there were a the total of 14 cases, indicating a reporting omission in the system in that year. The total number of unreported cases over the 7-year period from the NEDSS system was 29 cases, which represents a 35% discrepancy when compared to the reported cases.

The discrepancy in data between the two systems was explained by the focal point person and regional management of the JE surveillance system in the Northern region, NIHE. "*It results from the fact that reporting positive cases to the NEDSS system depends on the time of test processing and the hospitals where cases are detected. In some instances, individuals lived in Son La province but received treatment in other provinces, or patients were transferred to higher-level treatment facilities, such as central hospitals in Hanoi, rapidly, causing the Son La provincial surveillance system to miss recording these cases in the province's monitoring system."*

Table 4.5. *The number of JE cases reported in Son La province from the existing surveillance systems, 2016-2022*

	2016	2017	2018	2019	2020	2021	2022	Total
The NEDSS (A)	10	24	33	2	7	4	3	83
Sentinel JE surveillance system (B)	6	10	35	2	4	10	0	67
The number of cases reported in both system A and B ($C = A \cap B$)	1	7	29	0	1	0	0	38
The number of additional cases detected from system B (D = B-C) (D/A%)	**5 (+50%)**	3 (+12.5%)	6 (+18.2%)	**2 (+50%)**	3 (+42.9%)	**10 (+250%)**	0 (0%)	**29 (+34.9%)**
Total number of JE cases in Son La province {E = (A + B)-C}	**15**	**25**	**39**	**4**	**10**	**14**	**3**	**112**

4.11.3.4.2 Outbreak detection

All interviewees stated that the ability to detect JE outbreaks in the community is generally very high because most cases are reported on NEDSS, and the surveillance staff at various levels monitor NEDSS information daily.

NEDSS was implemented in Son La province in 2015. Before that, the surveillance system relied on paper reports, as well as information gathered through meetings and phone calls. A major outbreak in 2014 originated from a lychee orchard in one district (Song Ma District) and then spread throughout the province, with a total of 300 samples collected, detecting approximately 100 positive JE cases. Following this large outbreak, the entire province initiated numerous vaccination campaigns against JE for children under 15 years old.

Stakeholders' opinions about detecting the JE outbreak in 2014:

> *"Through the JE surveillance system report, we detected that outbreak. Without this report, we wouldn't have known about the outbreak in our region, hindering our ability to respond effectively." (Director of CDC Son La).*

Despite the most recent recognized local outbreak being in 2014, which falls outside the timeframe of the data used for this evaluation, this is mentioned to emphasize that the NEDSS system has evolved from the previous traditional surveillance system (paper and phone reporting). This highlights that, despite improvements over time, monitoring and detecting outbreaks remain a crucial part of this system's mission, and this ability could impact the response to any future outbreaks.

4.12 Discussion

Son La remains a high-risk province for JE in Northern Vietnam, although the disease incidence has decreased over time. The epidemiological characteristics align with previous reports on the surveillance system for this disease and the annual reports by WHO. The peak occurrence of cases is during the months of Jun to August each year, which is consistent with previous findings and weather patterns in the northern region of the country. Individuals under the age of 18 continue to be the primary affected group [7, 10, 14, 15]. The Thai ethnic group constitutes the majority of Son La's population, explaining the highest disease incidence in this group. However, it's noteworthy that the Mong ethnic group, which has the second-highest disease incidence, presents unique cultural factors such as vaccination hesitancy and limited access to healthcare. The nearly 10% mortality rate for JE in Son La underscores the significant disease burden.

Monitoring JE in Son La through NEDSS is just one of the data sources for JE surveillance and response. The JE sentinel surveillance system is also incomplete, as NEDSS was able to detect 45 (67%) additional cases compared to the sentinel system. This discrepancy suggests that while the sentinel system provides more detailed clinical and laboratory information, its coverage is limited, focusing primarily on selected hospitals. In contrast, NEDSS offers broader geographic coverage and may capture cases managed outside sentinel hospitals. Missing approximately one-quarter of JE cases in the NEDSS is a major weakness that limits its ability to detect outbreaks in a timely manner. While the sentinel surveillance system has helped compensate for this gap, it is not sustainable as it relies on external WHO funding. As sentinel surveillance is phased out, strengthening NEDSS with additional resources and practices from sentinel sites will be critical to ensure complete case detection and outbreak identification. To fully assess the impact of JE on the Sơn La community, data from various monitoring systems need to be combined, including JE sentinel surveillance system and laboratory data at all levels. Although the NEDSS is a national system, access to JE case data is restricted. Only authorized personnel - typically disease surveillance officers, outbreak response staff, and data management units - are granted permission to view and manage case information. This role-based access control protects patient confidentiality but can potentially limit the timely sharing of information between different levels of the health system. Nevertheless, the JE surveillance network has established defined roles, responsibilities, and communication pathways so that relevant staff are promptly informed when a JE case is detected.

In this chapter, I evaluated the JE surveillance system based on NEDSS. However, it may have been advisable to to also consider cases initially diagnosed as "Suspected viral encephalitis" in NEDSS to monitor the test results if available and to note cases of co-infection with JEV and one or more other agents.

As a passive surveillance system based on data primarily collected by sources at major hospitals, the ability to detect and comprehensively monitor JE cases in the community is limited because it relies on the capabilities of data entry personnel, early diagnosis by doctors, the time it takes to receive JE test results or even the voluntary visits of residents to healthcare facilities for medical examinations. NEDSS also has limitations in assessing trends in JE incidence in the community and the ability to accurately track the actual disease burden.

As a simple and reliable operational system, NEDSS allows authorized parties to access and quickly observe disease trends nationwide. The system also enables the extraction of case lists for in-depth analysis and long-term storage purposes.

However, because it is a minimalist system, some information about non-mandatory variables are often overlooked and therefore it lacks information on vaccination status, treatment outcomes, and complications. As mentioned above, it is entirely dependent on the capacity and dedication of each individual investigator and data entry officer as well as job pressure issues at healthcare facilities in the context of high rates of staff turnover. The discrepancy of 21 cases reflects incomplete updating of the Testing result variable in NEDSS, rather than true inconsistencies in laboratory findings. This highlights a limitation in data management, where surveillance officers may enter diagnostic classification but delay or omit updating the final laboratory result. Strengthening data entry procedures and routine data validation could improve accuracy and reliability of JE surveillance data.

Data completeness was limited as many important fields remained non-mandatory. Although vaccination status was a mandatory variable, the data collected largely relied on parental or caregiver recall rather than verified records. At the time of evaluation, linkage with the National Immunization Information System was not yet available, but given the small case numbers, follow-up and future data linkage would be feasible improvements. Regarding Data Completeness, there is a notable concern about the system's capability to identify JE cases, as it exhibits a sensitivity rate of merely 74,1% This suggests that a significant number of cases may not be captured by the system. Addressing challenges related to staff turnover, training, and capacity-building is crucial to ensure consistent and accurate data entry. However, improving sensitivity cannot be achieved solely through human resource measures. It also requires strengthening the overall surveillance system model, including clearer policies and procedures, standardized SOPs, better data integration across reporting sources, and enhanced monitoring and evaluation mechanisms to ensure data quality and case capture.

In terms of data quality, it is crucial to address and resolve discrepancies between laboratory findings and diagnostic categorizations. This step is vital for improving the overall accuracy of the data.There is a need for improvement in collecting vaccine-related data, as it currently relies heavily on patient or caregiver recollection, leading to unreliable information.The existing system predominantly depends on data from major hospitals, underscoring the need to enhance diagnostic capabilities and active community surveillance to gain a more comprehensive understanding of JE cases.

4.13 Limitation

A comprehensive review of the surveillance system was completed, however the small and convenient sample of interviewees, providing additional context was limited and may lack diversity and representation.

Limited access to NEDSS data, while important for confidentiality, may delay the dissemination of case information to all relevant health staff, particularly at peripheral levels. Although coordination mechanisms exist to notify responsible personnel when cases occur, reliance on these communication processes may still introduce delays in field-level response.

Another limitation is that certain discrepancies and weaknesses identified in the system were explained mainly through qualitative quotes rather than through systematic triangulation with additional quantitative data sources. The limited scope of available data prevented more in-depth cross-validation, which may have reduced the depth of explanation for some findings.

4.14 Recommendation

Here are some recommendations for the JE surveillance system in Son La can continue to evolve, becoming more robust, responsive, and effective in monitoring and controlling the disease:

Surveillance System Remodelling and Integration: The system should be remodelled to ensure better integration across the multiple existing surveillance platforms, including NEDSS, sentinel JE surveillance systems, and active community-based surveillance. Improving interoperability and data flow between these systems would enhance case detection, reporting consistency, and overall system efficiency.

Enhance Sensitivity: Efforts should be made to improve the sensitivity of the system. This can include refining case definitions, conducting regular training for healthcare staff to recognize JE cases, and promoting awareness among the public regarding JE symptoms and the importance of reporting. To achieve higher sensitivity, suspected cases should be consistently entered into NEDSS with appropriate follow-up, and mechanisms for data validation across systems should be established.

Strengthen Surveillance Management: Management of the surveillance system should be strengthened through clear assignment of responsibilities, enhanced supervision, and consistent implementation of Standard Operating Procedures (SOPs) and communication protocols.

Data Quality Assurance: Implement measures to ensure data quality. This can involve conducting regular data quality assessments, providing feedback to healthcare facilities for data improvement, and verifying laboratory results against diagnostic classifications. Data completeness was limited, as many key fields were non-mandatory and vaccination status relied on caregiver recall; linkage with the National Immunization Information System, though not yet available, would be a feasible improvement.

Community-Level Surveillance: Expand the surveillance system to include community-level surveillance. Establish mechanisms for reporting and investigating potential JE cases in rural and remote areas to capture a more comprehensive view of the disease's spread.

Continuous Training: Invest in continuous training and capacity-building for healthcare staff, especially in areas with high staff turnover. This ensures that new staff members are adequately trained and that experienced personnel stay updated on surveillance protocols.

Vaccine Information: Improve the collection of vaccine-related data. Explore options for integrating vaccine records with the healthcare system to reduce reliance on patient or caregiver recollections.

Public Awareness: Raise public awareness about JE and the importance of early reporting and vaccination. Public education campaigns can play a significant role in preventing the disease.

Technical Support: Provide technical support and guidance for healthcare facilities, especially those in remote areas, to ensure that they can effectively participate in the surveillance system.

4.15 Conclusion

In conclusion, the JE surveillance system in Son La, particularly through NEDSS, has made significant strides in disease monitoring and response. However, there is room for enhancement, particularly in terms of data completeness, staff training, and data accuracy. Addressing these challenges will help further strengthen the system's ability to monitor and respond to JE outbreaks effectively.

4.16 References

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4.17 Appendices

4.17.1 Appendix 4.1. List of Stakeholders

4.17.1.1 National NEDSS – Northern JE surveillance system

- Assoc.Prof. Pham Quang Thai, epidemiologist and general manager, Vice head of the Department of infectious disease prevent and control, NIHE.
- MD. Le Hai Dang, epidemiologist, focal point person for JE surveillance system in the North Vietnam, EPI unit, NIHE.
- MS. Le Thi Hien Thu, lab technician, Department of Virology, NIHE.

4.17.1.2 Son La CDC

- Dr. Nguyen Tien Dung, epidemiologist and general manager, Director of CDC Son La.
- MD. Nguyen Thi San, epidemiologist and general manager, Head of the Department of Infectious Diseases Prevention.
- MD. Cao Thanh Tung, epidemiologist, Vice head of the Department of Infectious Diseases Prevention.
- MD. Trinh Xuan Quan, epidemiologist officer of the Department of Infectious Diseases Prevention.
- MD. Bui Van Viet – The focal epidemiological officer responsible for JE sentinel surveillance in Vietnam, which includes overseeing the NEDSS.
- Bc. Dinh Thi Na - The focal epidemiological officer responsible for the NEDSS.
- Ms. Bui Huyen Trang - A laboratory staff member assigned to the preservation and transportation of JE samples.

4.17.1.3 Son La General Hospital

- Dr. Tran Quoc Khanh, medical doctor, Director
- MD. Nguyen Thi Hong Minh, data manager of the general planning department.

- MD. Tran Thi Thuy Ha, medical doctor, Head of the infection department.
- MD. La Thi Hai Cuc, medical doctor, the infection department.
- MD. Nguyen Trong Tung, Head of the department of hematology, microbiology blood transfusion and specimen preservation.

4.17.2 Appendix 4.2. Investigation form in Vietnamese

Mẫu điều tra ca Viêm não Nhật Bản

Mã số bệnh án :……………………………. …………… Mã số ca giám sát: …………

A. PHÂN LOẠI CA BỆNH

☐ **Nghi ngờ VNNB (cho giám sát VNNB tại BV tuyến tỉnh)**

B. NGUỒN THÔNG TIN

1. Tên bệnh viện: ☐Bệnh viện Nhi Trung ương ☐ Bệnh viện Nhi đồng 1 TP HCM
   ☐Bệnh viện Nhi đồng 2 TP HCM ☐ Bệnh viện khác: _______________
2. Họ tên bác sỹ: ____________________ Điện thoại: ________________________

C. THÔNG TIN CHUNG VỀ BỆNH NHÂN

1. Họ và tên: _________________________________ 2. Giới tính: ☐Trai ☐Gái
3. Ngày sinh: ____/____/_____ , nếu không rõ ngày sinh: Năm tuổi: ___ Tháng tuổi (nếu <60tháng tuổii): _____
4. Họ tên Bố/Mẹ: ______________________________ SĐT: _______________________
5. Nơi ở hiện tại: Số nhà_________ Đường______________ Thôn___________________
   Xã_______________ Huyện____________________ Tỉnh________________

D. TIỀN SỬ

1. Tiền sử tiêm chủng: (Nguồn thông tin: ☐ Hỏi ☐ Phiếu/Sổ tiêm chủng cá nhân)

Loại vắc xin		**Số liều**	**Ngày tiêm liều cuối**
a. VNNB	Có Ko KR	__	____/____/____
Vx bất hoạt từ não chuột (JEVAX-Vietnam)	Có Ko KR	__	____/____/____
Vx bất hoạt từ tế bào Vero	Có Ko KR	__	____/____/____
Vx sống giảm độc lực (SA14-14-2)	Có Ko KR	__	____/____/____
Vx sống tái tổ hợp (IMOJEV)	Có Ko KR	__	____/____/____
b. Vắc xin chứa thành phần Hib	Có Ko KR	__	____/____/____
(Pentaxim, Infanrix hexa, hexaxim, ComBE Five, SII, Hiberix, Quimihib, Quinvaxem…)			
c. Phế cầu	Có Ko KR	__	____/____/____
PCV10 (SYNFLORIX)	Có Ko KR	__	____/____/____
PCV13 (Prevnar)	Có Ko KR	__	____/____/____
d. Não mô cầu:	Có Ko KR	__	____/____/____
A+C	Có Ko KR	__	____/____/____
B+C	Có Ko KR	__	____/____/____
ACYW	Có Ko KR	__	____/____/____

2. Tiền sử tiếp xúc
   Có đi đâu trong vòng 2 tuần trước khi bị bệnh? Có (Nơi đến:___________) Ko KR
   Xung quanh có trường hợp nghi viêm não màng não? Có (Ai:___________) Ko KR
3. Có dùng kháng sinh trong vòng 7 ngày trước khi nhập viện không? Có(Loại KS: ____) Ko KR

E. TRIỆU CHỨNG LÂM SÀNG

1. Chẩn đoán nhập viện: ☐Nghi viêm màng não ☐Nghi viêm não-màng não ☐Hội chứng não cấp
   ☐Khác (ghi rõ): ______________________________
2. Ngày nhập viện: ______/______/______ Ngày khởi phát (triệu chứng đầu tiên): ______/______/______

Sốt (>38°C)	Có Ko KR	Đau đầu:	Có Ko KR	Co giật:	Có Ko KR
Lơ mơ:	Có Ko KR	Cứng gáy:	Có Ko KR	Thay đổi tinh thần	Có Ko KR
Nôn:	Có Ko KR	Thóp phồng:	Có Ko KR	Điểm Glasgow:	___ điểm

Mã số bệnh án :………………………………… Mã số ca giám sát: …………………………

F. KẾT QUẢ

1. Kết quả: ☐ Hồi phục/cải thiện ☐ Gia đình xin về ☐ Chuyển viện ☐ Tử vong ☐ Không rõ

Nếu tử vong, ngày tử vong: ______/____/_____ Nguyên nhân:………………………………………………………

Chẩn đoán ra viện: ___________________________Mã ICD:

2. Di chứng: Có Ko KR Ghi rõ di chứng (nếu có): ……………………………………………………………………………………………………

G. KẾT QUẢ XÉT NGHIỆM TẠI VIỆN VSDT TƯ/ PASTEUR Tp HỒ CHÍ MINH

Xét nghiệm tìm IgM kháng vi rút **Viêm não Nhật Bản**

Loại bệnh phẩm	Ngày lấy mẫu	Ngày nhận mẫu	Ngày xét nghiệm	IgM VNNB
Dịch não tuỷ	_____/_____/_____	_____/_____/_____	_____/_____/_____	□Dương tính / □Âm tính/ □Không rõ
Huyết thanh 1	_____/_____/_____	_____/_____/_____	_____/_____/_____	□Dương tính / □Âm tính/ □Không rõ
Huyết thanh 2	_____/_____/_____	_____/_____/_____	_____/_____/_____	□Dương tính / □Âm tính/ □Không rõ

H. Người điều tra (ký, ghi rõ họ tên)…………………………………………………… Chức danh người điều tra: ……………………………………

Ngày điều tra: ______/______/______ Ngày hoàn tất: ______/______/______

Thủ trưởng đơn vị (ký, đóng dấu)

4.17.3 Appendix 4.3. Questionnaire for interviewing

FIELD INTERVIEW ORIENTATION DOCUMENT

EVALUATION OF JAPANESE ENCEPHALITIS DISEASE SURVEILLANCE SYSTEM

IN SON LA PROVINCE, VIETNAM (data from 2016 to 2022)

Date: 19-21/04/2023

Interviewers:

1. Son La CDC:
   - The head of the Department of Infectious Diseases Prevention
   - 1 focal epidemiological officer/in charge of JE sentinel surveillance in Vietnam (including National Electronic Disease Surveillance System (NEDSS)).
   - 1 laboratory staff in charge of preserving and transporting JE samples.
2. Son La General hospital:
   - 1 Doctor and 1 nurse/1 lab staff involving in the diagnosis, investigation; sampling, presering and transporting JE samples.
   - 1 staff of the general planning department in charge of reporting the disease to the NEDSS.

Pre-prepared documents:

- Legal documents guilding and directing the supervision of JE surveillance at all levels
- Guidelines and toolkit for JE surveillance (Epidemiological investigation forms + test forms, report forms)
- Latest reports related to JE surveillance (regular reports: weekly/monthly/quarterly/yearly; ad hoc reports; technical team reports)
- Report on JE supervision of any third parties (if any)
- JE linelist:
  + Son La Provincial CDC: List of suspected JE cases for the period from 2016-2022 (full list sampled)
  + Son La General Hospital: List of suspected JE cases (ICD-10 code: A83.0) hospitalized at the Hospital in the period 2016-2022 (extracted from the hospital software).

QUESTIONNAIRE FOR INTERVIEWING

A. Interviewee info:

Name: …………………………………… Role/position: …………… DOB:…./…../…...
Location: ☐ Son La Provincial CDC ☐ Son La General Hospital
Phone……………………… Email:..

B. Work experience and training:

1. Work experience (…year(s)….months)

JE surveillance………….. NEDSS: ....
Treatment or caring for JE patients: ....
JE lab:..

P 1 of 6

2. Training:

	Latest time	Training units
JE surveillance system		
Statistical Report on NEDSS		

C. Research experience:

- In the past 10 years, has the unit conducted any research and / or published articles related to JE disease or JE surveillance system?

☐ Yes. ☐ No.

If yes, please describe……………………

D. Inspection and supervision:

- Is your unit inspected and monitored periodically for the JE surveillance system (annually)?

☐ Yes. ☐ No.

If yes,

- How many times? …………
- Do you have working records/response documents?.....................

E. JE surveillance SOPs:

1. Description of the surveillance process and Japanese encephalitis case reporting activities at your unit:

(Hint: Describe what activities, who does, who coordinates, tools, ..)

No.	Activities	Steps/ standards/ definitions	Doer	coordinator	Tools
1	Detecting cases				
2	Diagnosis				
3	Treatment				
4	Collecting specimens				
5	Preservation and transportation of JE specimens				
6	Sample testing and return/receive test results				
7	Reporting: - All kinds of reports - Time - Main contents - Frequency - Receivers …				
8	…				

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2. Draw out the flow chart of your JE surveillance system?

3. Has there ever been an JE outbreak which was declared by the local authority in Son La province from 2010 to present? (Describe scope and response scale?)

4. Evaluation of JE surveillance system's attributes in Son La province, 2016-2022:

a. Simplicity:

- Operating system in general at: simple - normal - complex?
- Which step is the most complicated and needs improvement/change?

b. Data Quality

JE investigation forms:

- Which variable is the most important variable that always needs information?
- Which variable is the most difficult to answer/collect/determine information?
- Which variable is the collected information only relative (not high accuracy)?
- Do you want or require to change anything about the investigation forms or process?

JE specimen form (of ISO LAB NIHE):

NEDSS: (Questions should base on a**ppendix**)

c. Flexibility

Changes that have occurred to the JE surveillance system:

- Surveillance system before NEDSS (before 2015)
- Time to apply the report to NEDSS (TT54 software in Son La)?
- Time to apply JE sentinel surveillance system and which sites: To what extent does it support to the JE general surveillance system?
- Changed questionnaires?
- Process of changing/updating (case definitions-clinical diagnosis-testing-outbreak response....)
- Changed cooperation (+/- stakeholders, parties...)
- Personnel changes
- Fundings….

What impact has the COVID-19 epidemic had on the surveillance and reporting of Japanese encephalitis cases in the years 2020-2022 in Son La province? (Stability*)

d. Sensitivity (not apply for the field trip):

Compare the number of positive cases from NEDSS/Total positive cases from all sources (including JE sentinel surveillance system-JESss)

What factors influence the disparity?

- NEDSS < All in the Son La community (JESss Sơn La+ JESss from other provinces)+NEDSS)

5. Usefulness of the JE surveillance system for the public health? *(with purpose to gain further insights from the stakeholders)*

6. Compared to the previous reporting system, what are the strengths and weaknesses of the report on the current NEDSS (Circular 54-case reporting software)?

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7. In your opinion, in order to perform well in surveillance and case management of JE, what points should be improved in the current JE surveillance system?

8. Some risk factors for the circulation of JE virus/JE disease in Son La:

a. Natural & livestock reservoirs: (Birds, pigs, cows, ...)
   For example: wet rice, agricultural crops, backwater, etc.)
b. Vector: Culex Mosquito

c. Vaccination: Review the JE vaccinne coverage of Son La province
- Ask the types of JE vaccines used in Son La province.
- Are there any vaccination gaps/ high-risk areas for vaccination in Son La?
- Are ethnic minorities difficult to access?

d. Other comments challenges or suggestions?

Appendix: The prelimirary results of Son La - NEDSS JE data:

□ ***Time:***

Year	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2016						1	6				3		**10**
2017	1	1			5	8	5	4					**24**
2018					5	4	14	7	2			1	**33**
2019						1		1					**2**
2020						3	1	1	2				**7**
2021						1	3						**4**
2022							1	2					**3**
Total	**1**	**1**		**0**	**10**	**18**	**30**	**15**	**4**	**0**	**3**	**1**	**83**

□ ***Place:***

No.	District	Positive case	Not results	Total
1	Quynh Nhai district	3	0	3
2	Bắc Yên district	4	2	6
3	Mộc Châu district	6	0	6
4	Sốp Cộp district	5	1	6
5	Yên Châu district	4	2	6
6	Phù Yên district	7	0	7
7	Sơn La city	7	0	7
8	**Sông Mã** district	**8**	**0**	**8**
9	**Thuận Châu** district	**8**	**0**	**8**
10	**Vân Hồ** district	**5**	**3**	**8**

No.	District	Positive case	Not results	Total
11	**Mai Sơn** district	**9**	**0**	**9**
12	**Mường La** district	**9**	**0**	**9**
	Total	**75**	**8**	**83**

Hospitals	Hospital for treatment	Reporting units			
	Incidence/ deaths	+case /No results	Total case	Timeliness	Overdue
National Hospital for Tropical Diseases	2	2/0	2	0	2
Bắc Yên general district hospital	2	2/0	2	0	2
Sông Mã general district hospital	6	6/0	6	0	6
Phù Yên general regional hospital	2	4/0	4	0	4
Thảo Nguyên general hospital	4	1/3	4	0	4
Sơn La general provincial hospital	**42/5**	**39/5**	**44**	**2**	**42**
National hospital of children	**21/2**	**19/0**	**19**	**3**	**16**
CDC Son La	1/1	0	0	0	0
Phù Yên district heatlh central	2	0	0	0	0
Tuần Giáo district heatlh central	1	1/0	1	0	1
Mường La general district hospital	0	1/0	1	0	1
Total	**83/8**	**75/8 (90,4%)**	**83**	**5 (6%)**	**78**

? Reasons for Overdue?

Persons:

- Age:

Age group	cases	%
<1y	11	13%
1- <2y	1	1%
2- <5y	13	16%
5 - <18y	39	47%
>=18y	19	23%
Total	**83**	**100%**

- Sex: Male 53 (64%) – Female 30
- Outcomes:

Outcomes	Cases
Inpatients	14
Discharge	61
Deaths	**8**
Total	**83**

- Ethnicity:

No.	Ethnicity	cases	%
1	Dao	1	1,2%
2	Kinh	7	8,4%
3	**Mong**	**22**	26,5%
4	Muong	8	9,6%
5	**Thai**	**43**	51,8%
6	Xinh mun	2	2,4%
7	**Total**	**83**	**100,0%**

- JE vaccine status:

JE vaccine status	cases
Yes	4
No	40
Unknown	39
Total	**83**

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- Diagnosis:

classify	Cases
Clinical cases	29
Lab-confirmed cases	54
Total	**83**

 ?21/75 lab-confirmed cased had been updated test results?

- Test type:

Test types	Cases
Other	5
Mac-elisa	68
PCR	2
Unknown (blank)	8
Total	**83**

- Test results

Test results	Cases
Positive	75
(blank)	8
Total	**83**

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Figure 4.11. Meeting at the Son La CDC

Figure 4.12. Working at the Son La general provincial hospital

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Chapter 5. An epidemiology study

Analyzing trends and predicting future outbreaks of Measles in Vietnam using time series analysis

List of Abbreviations – Chapter 5

ANU	Australian National University
MAE	Master of Applied Epidemiology Program
NIHE	National Institute of Hygiene and Epidemiology
COVID-19	Coronavirus Disease 2019
WHO	World Health Organization
EPI	Expanded Programme on Immunization
ANU HREC	Australian National University Human Research Ethics Committees
NEDSS	National Electronic Disease Surveillance System
EPIPOI	Analytical Software for Epidemiological Time Series
PAF	Periodic annual function
MCV	Measles containing Vaccine
IQR	interquartile range
EPI	Expanded Programme on Immunization

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5.1 Prologue

5.1.1 My role

When I conducted the data analysis project on the topic of measles at the National Children's Hospital in Hanoi (Chapter 3), I was very curious to learn more about the national-scale measles model in Vietnam and to understand if there were regional differences. I proposed the idea of undertaking this project to my supervisors, and they approved and guided me through the process.

I was appointed as the joint leader of this project along with my field supervisor. We proceeded to outline the research, reported to the NIHE leadership, and obtained approval to access data stored on NIHE's platforms. Alongside my academic supervisor, I submitted an ethics application to ANU HREC and received approval before commencing data collection. Data collection took longer than expected, approximately three months. Initially, I had anticipated that data could be collected entirely from the year books maintained at NIHE. However, this source was disrupted from 2019 to 2022 due to changes in reporting mechanisms and the COVID-19 pandemic context.

I collaborated with stakeholders at different levels using various approaches under the guidance of the field supervisor. Eventually, we reached a consensus to utilize data reported from the National Electronic Infectious Disease Reporting System (NEDSS). I worked with the data manager, extracted and cleaned the data, encoded it, and transformed it into a format ready for analysis. To perform the data analysis, I conducted various analyses using excel, R, and EPIPOI software, including descriptive epidemiology, forecasting models, and time series techniques. Finally, based on the analysis results, I compiled the findings and conducted discussions, along with providing insights into measles outbreaks at both the national and regional scales in Vietnam.

5.2 Lessons learned

Through this project, I have gained valuable insights and experiences that have enriched my understanding of epidemiology and infectious diseases as well as academic research skills, as follows:

My expanding my experience with EPIPOI software allowed me to enhance my technical skills in time series data analysis and advanced interpretation. I faced numerous challenges while diving deep into the techniques involved in analyzing time series data, forecasting models, and algorithms utilized in software like EPIPOI. This experience taught me the importance of continuous learning and adaptability, as the field of epidemiology constantly evolves.

EPIPOI, a disease trend forecasting software, proved to be a valuable tool in the field of applied epidemiology. It offers various features for data visualization, trend analysis, and the identification of seasonal patterns in epidemiological data. Through this experience, I realized that EPIPOI can play a crucial role in helping researchers and public health practitioners better understand and analyze data related to infectious disease outbreaks.

Furthermore, this project has reinforced the idea that disease models are not solely influenced by traditional factors such as agent characteristics, epidemiological features, and healthcare-related variables. There are many external elements that play a crucial role in shaping disease patterns, including climate, weather, geographical factors, and even cultural practices. This holistic perspective has broadened my approach to studying and analyzing infectious diseases.

Analyzing time series data for measles in Vietnam deepened my understanding of the regional variations in disease patterns. This knowledge is essential for tailoring public health interventions to the specific needs of different areas, acknowledging the unique characteristics and challenges presented by each region.

5.3 Public health impact

This study aimed to analyze the epidemiological characteristics of measles time series data and forecast patterns of measles outbreaks for the next 5 years. The findings will contribute to a comprehensive understanding of measles epidemiology in Vietnam, potentially guiding policy decisions, service provision, prevention strategies, including MCV campaigns, and other public health interventions from the national level down to the provincial level, all aimed at safeguarding the Vietnamese population.

Conducting this study in Vietnam holds the benefit of providing evidence-based data that will allow the Vietnamese vaccination and public health programme to target measles focused prevention activities and the national EPI program. In particular, the identification of seasonal peaks and regional differences can inform the optimal timing and geographic targeting of supplementary immunisation activities. The findings also highlight the urgency of restoring and sustaining high MCV1 and MCV2 coverage after the COVID-19 pandemic to prevent resurgence, and can support both national and provincial policy makers in strengthening surveillance, outbreak preparedness, and measles elimination strategies.

5.4 Ackowledgements

I would like to extend my sincere appreciation to my academic supervisor, Assoc. Prof. Samantha Colquhoun, and Associate Prof. Pham Quang Thai, my field supervisor. Their unwavering support and encouragement have been instrumental in helping me believe in my abilities and maintain a positive attitude throughout this endeavor.

I am also grateful to my former academic supervisor, Dr. Florian Vogt, as well as another field supervisor, Dr. Nguyen Cong Khanh, and several colleagues from Dr. Thai's research team for their invaluable assistance.

I also wish to express deep gratitude to MSc. Tran Duc Hieu, Computer Scientist, Institute of Applied Mechanics and Informatics, Vietnam Academy of Science and Technology, for his contributions in helping me understand and interpret the results of the analytical techniques in this project.

5.5 Master of Philosophy in Applied Epidemiology core requirements

✓ Design and conduct an epidemiological study

5.6 Abstract

Background:

Measles remains a significant public health concern in Vietnam, with recurring outbreaks impacting various regions of the country. Understanding the seasonal and geographical patterns of measles is crucial for effective prevention and control measures. This study aims to shed light on these patterns, assess the influence of seasonality and examine the measles forecasting model for the next five years.

Methods:

Historical data on measles cases in Vietnam from 2003 to 2022 were analyzed. Seasonal decomposition of time series data was used to examine the seasonal characteristics of measles. The Holt-Winters exponential smoothing method was applied to forecast measles cases for the next five years.

Results:

The analysis demonstrated the regularity of measles outbreaks in Vietnam, with significant occurrences in 2009-2011, 2014, and 2018. Measles exhibits an annual cyclical pattern, peaking from February to June during the spring and summer seasons, with the southern region experiencing this cycle about one month earlier than the northern region. The disease is notably prevalent in densely populated major cities. While historical data show a 4-5 year cyclical pattern of major outbreaks, the forecasting model for the next 5 years suggests a declining trend with a wide 90% confidence interval, indicating potential issues related to overfitting.

Discussion:

The annual seasonality of measles and the recurring pattern of large outbreaks suggest that there are still gaps in current measles intervention measures. This indicates the need for proactive monitoring and increasing vaccination rates during these times. Forecasting measles remains challenging due to various factors, such as vaccination rates, population dynamics, and weather conditions, which require further research to develop a more accurate and realistic forecasting model.

Conclusion:

Measles in Vietnam exhibits a stable seasonal pattern, occurring during the spring and summer months, with major outbreaks appearing every 4-5 years, and future forecasts showing continued variability. Although the forecasting model for the next five years indicates a declining trend, it is important not to be complacent in light of declining MCV coverage during and after the COVID-19 pandemic. This underscores both the challenges of prediction and the need to integrate additional factors such as vaccination coverage, population mobility, and post-pandemic changes.

5.7 Introduction

Measles is a contagious infectious diseases with high associated morbidity and mortality, especially in children. Common symptoms of measles are high fever, cough, runny nose, watery eyes appear 7-14 days after infection, Koplik spots and a rash. Many countries have high measles vaccination rates but have experienced outbreaks when imported cases cause transmission through susceptible populations who are not immune to the measles virus [1].

Measles transmission is strongly influenced by seasonal patterns, typically peaking during the dry season in tropical climates and during late winter or early spring in temperate regions [2].

These seasonal dynamics are driven by climatic conditions, population mobility, and the accumulation of susceptible individuals. Understanding seasonality is therefore critical in developing robust forecasting models. Vietnam lies predominantly within the tropical monsoon climate zone, although climatic conditions vary by latitude and altitude. The northern region experiences a humid subtropical climate with distinct seasonal variation, while central and southern regions are characterized by a tropical climate with clearly defined rainy and dry seasons. Highland areas such as Da Lat (South) and Sa Pa (North) exhibit temperate features due to elevation.

In Viet Nam, in the National Expanded program on Immunization, Measles containing Vaccines (MCVs) are given in a 2 dose schedule, at 9 months and 18 months of age. Vietnam's immunisation strategy emphasizes timely vaccination according to schedule, with catch-up vaccination recommended as soon as possible for children who have missed or delayed doses, in accordance with Ministry of Health and manufacturer guidelines. In addition to routine services, supplementary immunisation activities (SIAs) and mass vaccination campaigns are implemented when necessary, particularly in outbreak settings or where gaps in population immunity are identified. While there is currently no mandatory measles vaccination requirement for international travellers entering Vietnam, within the country the Law on Prevention and Control of Infectious Diseases allows for mandatory vaccination of at-risk groups in outbreak situations. Such measures may be enforced by provincial authorities under the guidance of the Ministry of Health, depending on epidemiological conditions, vaccine availability, and local resources.

The National EPI and the Ministry of Health of Vietnam have set a timeframe to achieve the goal of measles elimination in Vietnam by 2017, based on global and regional goals outlined in Vietnam's comprehensive Multi-Year Plan (cMYP) for 2016-2020 [3]. However, in reality, measles is an infectious disease with highly complex dynamics, heavily dependent on the natural epidemic cycles as well as the variations in climate and weather conditions each year. It does not solely adhere to the rules of community immunity acquired mainly through systematic vaccination. From 2013 to 2018, Vietnam was one of the five countries with the highest incidence of measles in the Western Pacific region, with large measles outbreaks occurring in 2014 and 2018-2019 [4]. Measles outbreaks in Vietnam occurred mainly in children under 5 years old. Of these many recorded cases were in infants. Infants under nine months of age are ineligible for vaccination, making them highly vulnerable where there is not adequate vaccination coverage in the population leading to lower herd immunity, or where with high-risk infection such as hospital environment and in kindergartens, pre-school age. This has placed a increased burden on health workers, families and society, especially during the recent major outbreaks.

The measles incidence in Vietnam has shown a clear inverse relationship with vaccination coverage over the past decades [5]. When MCV1 and MCV2 coverage was consistently above 95%, incidence declined markedly, approaching elimination levels. However, whenever coverage dropped below 90%, such as in 2014 and 2019, large outbreaks occurred, highlighting the fragility of herd immunity. During the COVID-19 period, reported cases decreased, but disruptions in immunization services and surveillance may mask an increased risk of resurgence in the coming years (Figure 5.1).

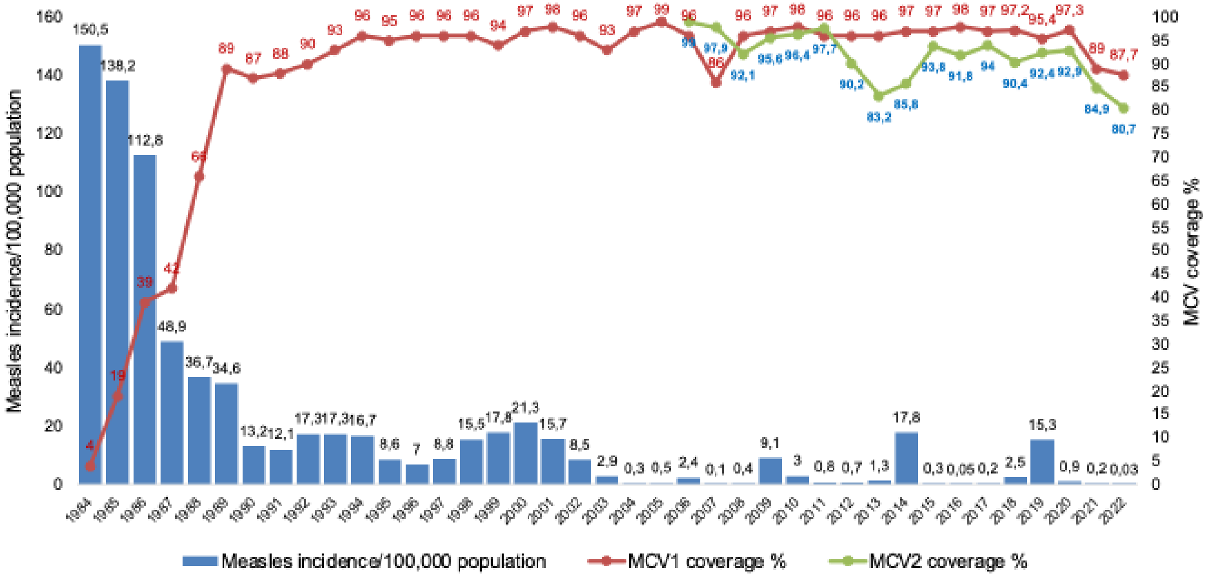


Figure 5.1. Measles vaccination coverage among children and measles incidence, 1984–2022

(Since 2002, supplementary immunisation activities (SIAs) and mass vaccination campaigns have been conducted regularly, with target groups determined based on epidemiological assessments: 2002, 2012, 2016: Nationwide MCV1 campaigns; 2005, 2009–2010: MCV1 campaigns in high-risk areas; 2006–2013: MCV2 campaigns (children aged 6 years); 2014: Introduction of MCV2 (MR vaccine) into the NEPI for children at 18 months of age; 2017: MR campaign for adolescents aged 16–17 years; 2018–2020: MR campaign for children aged 1–5 years; 2022: MR SIAs for children aged 1–5 years)

According to national immunization reports, the proportion of children under 1 year receiving MCV1 through routine immunization reached 89% in 2021 and 87.7% in 2022, while MCV2 coverage at 18 months was 84.9% and 80.7% respectively, well below the ≥95% target. This translates to an estimated 165,000 children missing MCV1 and 231,000 missing MCV2 in 2021, increasing to 193,000 and 300,000 children, respectively, in 2022. These figures are consistent with WHO/UNICEF estimates, which reported MCV1 coverage of 88% and MCV2 coverage of 81% in 2022 [6]. Vietnam has implemented catch-up and mop-up vaccination campaigns, particularly targeting high-risk, hard-to-reach, and ethnic minority populations. Recent reports suggest that these supplementary efforts increased coverage by an average of around 7%. Nevertheless, gaps persist, especially at commune and village levels, where susceptible children continue to accumulate. These weaknesses may be compounded by limitations in administrative reporting systems, such as reliance on denominator estimates of target populations and difficulties in reaching mobile or marginalized groups. Such factors help explain why substantial measles outbreaks have continued to occur in Vietnam despite apparently high national coverage levels.

Vietnam shares long, porous borders with Cambodia, Lao PDR, and China, which creates an ongoing risk of measles importation and cross-border transmission. Analyses of the 2014 and 2018–2019 epidemics suggest that outbreaks were amplified in areas with lower or uneven vaccination coverage, particularly in remote border provinces and highland communities, where access barriers and socioeconomic disparities persist [7,8]. Imported cases from neighbouring countries have repeatedly been implicated in measles resurgences in the Western Pacific region, and similar dynamics have been documented in border areas of China and Southeast Asia [9, 10]. These findings underscore that even with high national coverage, subnational immunity gaps leave Vietnam vulnerable to importation-driven outbreaks, reinforcing the importance of strengthened surveillance and targeted supplementary immunisation in border provinces.

Vietnam manages measles outbreaks through a combination of strengthened surveillance, outbreak investigation, and targeted immunisation activities under the guidance of the Ministry of Health. Core measures include case detection and mandatory reporting, epidemiological investigation of outbreaks with contact tracing, isolation and case management, infection prevention and control in healthcare facilities, and risk communication to the public [11]. When significant outbreaks occur, or when immunity gaps are identified in particular regions, the Ministry of Health and provincial authorities may implement supplementary immunisation activities (SIAs) or outbreak response immunisation (ORI) campaigns to rapidly increase population immunity. These campaigns are often combined with other public health measures, such as strengthening hospital preparedness and providing guidance to schools and kindergartens on infection control. The legal framework for outbreak investigation and response allows provincial People's Committees, under the direction of the Ministry of Health, to enforce temporary mandatory vaccination of at-risk groups in outbreak settings [12]. Clinical management of measles cases is also standardised through national protocols [13].

Experience from the large epidemics in 2014 and 2018–2019 demonstrated that while mass vaccination campaigns and catch-up immunisation were effective in reducing the immediate number of susceptible individuals, sustained prevention requires addressing routine immunisation gaps at the community level and maintaining rapid surveillance and response capacity.

In Vietnam, knowledge and attitudes toward measles vaccination are generally positive, but significant disparities remain. Studies have shown that children from ethnic minority groups, rural and mountainous areas, and lower socioeconomic households are less likely to receive timely or complete vaccination, contributing to immunity gaps and large outbreaks such as in 2014 [9,14]. In addition, serological surveys indicate that many infants lose maternal measles antibodies before the age of 9 months, leaving them vulnerable prior to receiving the first scheduled vaccine dose [15,16]. These findings highlight that both social inequalities and biological susceptibility shape measles risk in Vietnam, underscoring the need for strengthened immunisation strategies.

Time-series analysis is a well-established statistical approach in infectious disease surveillance and forecasting [17]. It enables the modeling of temporal structures in epidemiological data, including long-term trends, seasonal variation, and random fluctuations. By capturing these dynamics, time-series models can generate short- and medium-term forecasts and support the early detection of unusual patterns that may indicate an outbreak. Undertaking disease forecasting is a crucial aspect of planning and decision-making in various scenarios. Effective forecasts reveal the genuine underlying patterns and connections in historical data, avoiding the replication of past events that are unlikely to recur. Rather than simply identifying the current state of play, forecasting models aim to capture how disease transmission may evolve over time.

To date, no published studies have specifically applied time-series forecasting models to measles in Vietnam. However, internationally, recent research has applied time-series forecasting methods to measles. For example, the study “Predicting epidemics using search engine data: a comparative study on measles in the largest countries of Europe” in 2021 [18] combined official surveillance data with Google Trends queries, showing strong correlations with reported cases and the ability to anticipate outbreaks up to two months in advance. In the Philippines, “Analyzing Trends and Predicting Future Outbreaks of Measles Using Time Series and ARIMA Mathematical Models” in 2021 [19] applied ARIMA models to national measles data and forecasted a high burden of cases between 2017 and 2019, followed by a gradual decline in the subsequent five years, though case numbers remained substantial.

In Vietnam, while no measles forecasting studies exist, forecasting methods such as ARIMA and machine learning approaches have been applied to other infectious diseases. For example, Pham NT et al. in 2020 [20] applied ARIMA models to dengue surveillance data in southern Vietnam and reported reasonable short-term predictive accuracy, although challenges such as underreporting and environmental variability limited performance. Moreover, Holt–Winters exponential smoothing has repeatedly shown good performance in forecasting infectious diseases where seasonality is strong, offering the advantages of simplicity, transparency, and interpretability. In Thailand (Ubon Ratchatani), Holt–Winters outperformed ARIMA/SARIMA for dengue forecasts [21], and in Sri Lanka (Colombo), it successfully fitted both raw and log-transformed dengue case data [22].

This project focuses on time series data collected at regular intervals (monthly), with the objective of predicting the future trajectory of these observations. The intention aims to facilitate the formulation of proactive intervention strategies in Vietnam's healthcare sector, spanning from the national level down to the provincial level, with the ultimate goal of safeguarding the health of the population.

5.8 Methods

5.8.1 Study design

This was a retrospective study using NIHE available data on the number of cases collected from year books or official reports, with no personal information or intervention or interaction with the patient.

5.8.2 Objectives

The project aimed to analyze the epidemiological characteristics of measles in Vietnam from 2003 to 2022, and to create models for forecasting future patterns of measles outbreaks:

A. To determine the trend and cycle of measles during 2003 – 2022 and examine some factors influencing the cyclicality of the outbreak in Vietnam.
B. To predict the possibility of measles outbreaks occurring within the next 5 years in Vietnam.

5.8.3 Data collection and Case definitions

Data are a 20-year sample consisting total number of measles cases by month by province (n=63) in the whole of Vietnam. These de-identified data are routinely collected public health data for the purpose of monitoring and evaluating the measles situation in Vietnam. The study population were all measles cases reported between 1 January 2003 to 31 December 2022 in Vietnam.

I collected available data from the yearbooks at NIHE for the data of the year from 2003 to 2018. However, for the data from 2019 to 2022, there were no yearbooks due to the interruption caused by the COVID-19 pandemic. Therefore, I extracted data from the NEDSS system (in the form of case lists), cleaned it, and entered it into a data table, formatting it into this dataset.

The definition of a measles case was based on the National EPI guidelines [23] and Decision No. 4845/QD-BYT "Guidelines for monitoring and preventing measles and rubella", issued on December 5, 2012 [11]. The reported measles cases in this study were all laboratory-confirmed cases or, in the case of outbreaks, clinical or epidemiological cases as defined by the guidelines of the Vietnamese Ministry of Health. Even though the data I collected were based on officially classified and reported results, I still want to present here the definitions and classifications of measles cases that have been used in the healthcare context of Vietnam as follows:

- **Suspected case:**

  A case with the following symptoms:

  + Fever and
  + Skin rash and
  + At least one of the following symptoms: cough, runny nose, conjunctivitis, lymphadenopathy (neck, armpit, or groin), painful swelling of the joints.

- **Probable case:**

  A suspected case of measles/rubella for which no specimen was taken or the specimen was not properly collected, and there is no epidemiological link to a laboratory-confirmed measles case or another laboratory-confirmed communicable disease case. However, it presents at least one of the three symptoms: inflammation of the lung (cough, runny nose, conjunctivitis).

- **Clinical case:**

  It presents symptoms of fever, skin rash, cough, red eyes (conjunctivitis), and runny nose.

- **Epidemiologically confirmed case:**

A suspected measles/rubella case without a specimen taken but with an epidemiological link to a laboratory-confirmed measles case or a laboratory-confirmed case of another communicable disease. The contact or potential contact occurred in the same space and time, with an interval of 7 - 21 days between the onset of rash in the two cases.

- **Laboratory-confirmed case:**

  A case diagnosed with measles based on one of the following tests:

  + ELISA test with specific IgM antibodies against the measles virus.
  + PCR test that identifies a specific segment of the measles virus genome.
  + Isolation of the measles virus.

- **Excluded Measles Case:**

  A suspected measles case with a properly sampled clinical specimen that tests negative for measles or is conclusively diagnosed with another disease.

- **Measles Outbreak:**

  Measles outbreaks occur when there are three or more confirmed measles cases within one district in a month. These cases must be epidemiologically or virologically linked (with an interval of 7 to 21 days between the onset of rash in any two cases), and at least two of these cases should be confirmed through laboratory testing.

5.8.4 Location

This study analyzed nationwide data. Vietnam is divided into 63 administrative provinces and municipalities and has five main levels of administrative management, from low to high: Commune-District-Province-Region-Central. **Healthcare management regions** are categorized, meaning that these provinces are grouped together under regional management, which differs from national administrative management. For example, in healthcare, there are four regions, as I mentioned in this text, with the Central Highlands and Central regions considered part of the "Central Region" in administrative management. So, administrative management only has three regions. This analysis not only provides an overview of measles characteristics in Vietnam as a whole but also delves into specific **healthcare management regions**, which I will refer to as "**regions**" for this study, as described below.

In the healthcare system, the Ministry of Health divides the management regions into four areas: Northern region with 28 provinces/cities, Central region with 11, Central Highlands with 4, and Southern region with 20 (Figure 5.2).

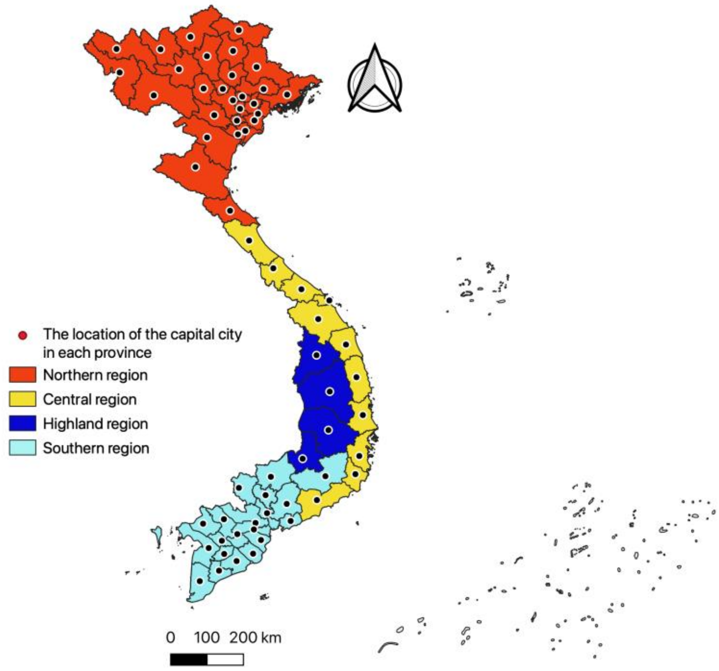


Figure 5.2. Map of Vietnamese 4 healthcare management regions

Black dots indicate the location of the capital city in each province. The colors represent 4 different healthcare management regions: Red - 28 provinces in the Northern region, Yellow- 11 provinces in the Central region, Blue - 4 provinces in the Highlands, and Turquoise - 20 provinces in the Southern region.

5.8.5 Data analysis

We used a time series analysis performed using EPIPOI software [24] (http://www.epipoi.info) and R software. For descriptive analysis, I also utilized QGIS and Microsoft Excel software to assist in visualizing the data.

Analysis of historical data was conducted to provide seasonal parameters from the time-series, examine trends and identify unusual periods (epidemic peaks) and other trends. Next, we conducted a predictive analysis of historical data to forecast future measles patterns.

5.8.5.1 Time-series analysis [17, 24-26]

Time series data may display diverse patterns, and it can be beneficial to divide a time series into various components, each representing a distinct underlying pattern category. It is commonly typically merge the trend and cycle into a single trend-cycle component, often referred to as just the "trend." Consequently, we can conceptualize a time series as consisting of three components: a trend-cycle component, a seasonal component, and a remainder component (including any other elements in the time series).

Measles time series data is seasonal data and comprises two main components: the systematic component (regular component) and the unsystematic or random component (irregular component). To denote the data series as Y, and to separate these two components, we need to estimate the trend component, denoted as T_t, the seasonal component, denoted as S_t, and the residual component, denoted as E_t:

$$Y_t = S_t + T_t + E_t$$

To analyze these components, we use the **'decompose()'** function in R to get a general view of the components, and then we apply specific data transformation techniques within the EPIPOI software.

Surveillance data inevitably present quality challenges, including underreporting, and changes in surveillance practices over time (e.g., case definitions or healthcare-seeking behavior). These factors can complicate analysis if raw notification data are used directly. To address this, we applied **data transformation techniques** - including square root transformation and polynomial detrending - to stabilize statistical properties. Such techniques helped reduce random noise, limit the impact of long-term reporting fluctuations, and prepare the dataset for **Fourier** and **Wavelet analysis**. By applying **detrending** and other transformations, we were able to highlight the underlying structures more clearly, which improved the visualization and interpretation of cyclical and seasonal measles dynamics. This provided a stronger basis for quantitative forecasting and informed public health recommendations.

Utilizing surveillance data comes with various quality issues, encompassing both issues of underreporting and overreporting, as well as changes in the surveillance system over time, such as modifications in case definitions or shifts in healthcare practices. These intricacies can introduce complexities in the analysis and comprehension of the data when relying solely on the raw notification values. Faced with these challenges, our strategy entailed the application of qualitative analyses guided by statistical methods that exhibit lower sensitivity. The described data transformations are fundamental prerequisites for enabling these qualitative analyses.

In the context of this measles data analysis, **data transformation techniques** were applied to prepare time series data for analysis. **Detrending** is a form of data transformation. These forms were used to stabilize statistical properties, making the data suitable for **Fourier** and

Wavelet analysis to better understand the cyclical patterns and identify potential outbreaks. By removing noise and trends, these techniques can reveal the fundamental dynamics of the disease and aid in making informed public health decisions.

5.8.5.2 Data transformation

The square root transformation was applied in EPIPOI for this study to stabilize the variance and make the data more amenable to analysis. Data transformation using **a square root transformation** involves taking the square root of each data point in your dataset. It is a common technique used for handling data with nonlinear relationships between the mean and variance. This transformation can help make the data more symmetric and reduce the influence of extreme values.

5.8.5.3 Detrending

We used the **"detrend by polynomial"** method for this study. This technique involves removing underlying trends in the data by fitting and subtracting a polynomial function that best represents the trend component. By detrending with a polynomial, the analysis aimed to isolate and examine other patterns, variations, or components in the time series data, providing a clearer understanding of the measles outbreaks in Vietnam. This approach helps us focus on factors beyond the trend and better interpret the data for epidemiological insights.

5.8.5.4 Fourier analysis

Using Fourier analysis to detect changes in seasonality across the study period. Fourier transformation is a widely used signal decomposition method that breaks down signals into their cyclic components using sinusoidal functions. By this method, we possibly identify the number of epidemic peaks and then the rule of moving these peaks. However, Fourier analysis is typically applied to stationary data, which means that the statistical properties, such as the mean and variance, remain constant over time. Since the data in this measles time series study is non-stationary, we have employed preprocessing techniques, including detrending, to stabilize the statistical properties over time and make the data suitable for Fourier analysis.

5.8.5.5 Wavelet transform

Wavelet transform is an other powerful tool for analyzing time series data, especially when dealing with non-stationary, complex data like measles outbreaks. Indeed, wavelet transforms can be considered a logical extension of Fourier transforms. Wavelet transform, unlike Fourier decomposition which breaks down a signal into sinusoids, dissects a signal using wavelet basis functions. Wavelets can be seen as sinusoids that are modulated by an envelope. For instance, the commonly used Morlet wavelet in ecology combines a sine wave with a Gaussian envelope (see Figure 5.3).

The method transforms a signal f(t) into a function W(a,b), as defined by equation 5.1, which demonstrates the various frequency components at time (t).

$$W(a,b) = \frac{1}{\sqrt{a}}\int_{-\infty}^{+\infty} x(t)\varphi^*\left(\frac{t-b}{a}\right)dt = \int_{-\infty}^{+\infty} x(t)\varphi^*_{a,b}(t)dt \qquad (5.1)$$

Equation 5.1. involves using the complex conjugate form *, where $W(a,b)$ represents the wavelet coefficients with "a" denoting the wavelet frequency (scale) and "b" indicating the time position difference. The function x(t) corresponds to the formula at time t, and φ represents either the scaling function or the wavelet itself.

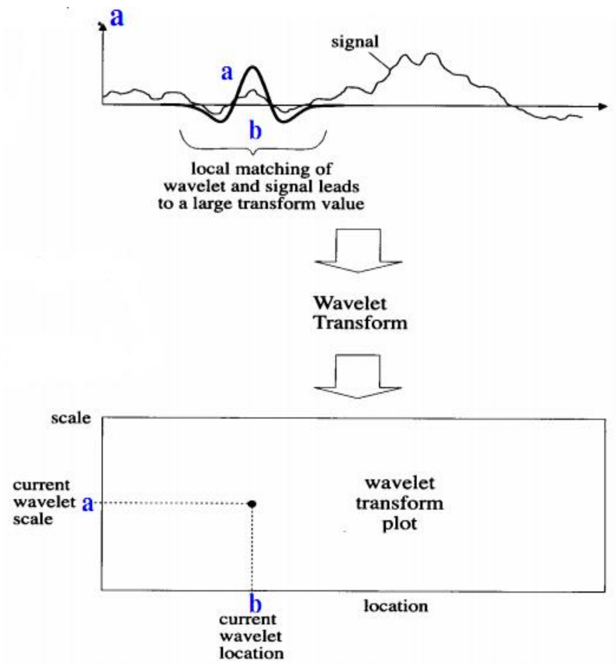


Figure 5.3. Wavelet transformation of a time-series [26]

"a": is the wavelet frequency
"b" is the time centre of the wavelet.
Signal is multiplied with a wavelet function, then analyzed the frequency at different times. After the wavelet transform in coordinates $W(a_i,b)$ with i =1, 2, 3 ... n we obtain the set of points in rows which show which frequency component appears at the time "t". When "b" changes with i =1, 2, 3 ... n we obtain a set of points in columns. These values are expressed in the spectral method with the gradually bold colors depending on the rule and frequency (Figure

5.4). Identifying the high frequency appearing at a time help us determine the circulation of epidemic.

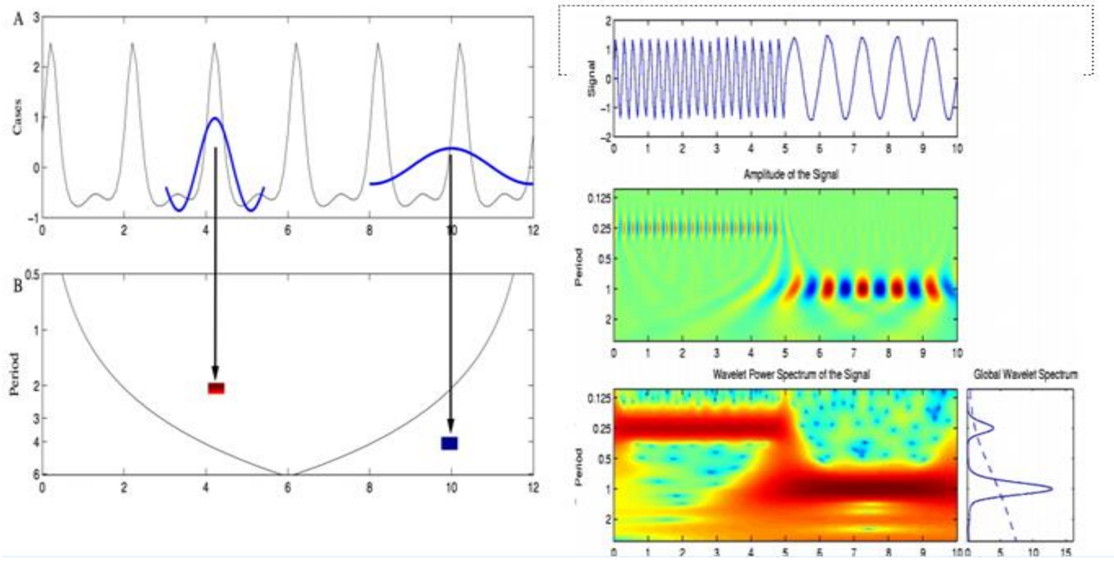


Figure 5.4. Time-dependent spectral analysis of epidemiological time – series with wavelets [26]

When dealing with a time series composed of two periodic signals with distinct periods, like an annual pattern combined with a multi-annual one, each of these signals possesses a phase, representing a specific period within them. The coherence between two wavelets can be likened to a linear correlation measurement between them. Its construction is similar and exists within the range of 0 (indicating no correlation) to 1 (indicating perfect correlation). This metric provides insights into when and around which period two time series exhibit stronger linear correlation.

Wavelet analysis offered valuable insights into the historical trends of the measles time series in Vietnam, shedding light on periodic patterns and temporal variations. These findings were instrumental in shaping the development of forecasting models. In this study, we employed the **Holt-Winters exponential smoothing method** within the R software to predict future patterns of measles outbreaks.

5.8.5.6 Holt-Winters exponential smoothing method [27]

This method applied in R for this study involves a time series forecasting technique that takes into account seasonality and trends. It utilizes three main components:

- Level (α): Representing the base level of the time series.
- Trend (β): Capturing the directional movement or trend in the data.

- Seasonality (γ): Accounting for seasonal variations in the time series.

The method uses these components to forecast future values by extrapolating the base level, trend, and seasonality patterns.The smoothing parameters (α, β, and γ), each having a value between 0 and 1, play a crucial role in determining the weights assigned to the respective components in the Holt-Winters exponential smoothing method. These parameters are estimated using historical data to best capture the patterns and variations in the time series.This approach provides a powerful tool for making predictions based on the patterns observed in the time series.

The value α (alpha) is the smoothing parameter for the level component in the Holt-Winters exponential smoothing method. It controls the weight assigned to the most recent data point when updating the level component of the time series. A smaller α places less weight on the most recent observation, allowing the model to be more responsive to recent changes in the data, while a larger α gives more weight to the latest observation, making the model more stable and less responsive to short term fluctuations.

β (beta) represents the smoothing parameter for the trend component. It controls the weight assigned to the most recent observation when updating the trend. A smaller β places less weight on the most recent trend, making the model less responsive to short-term fluctuations in the data, while a larger β gives more weight to the latest trend, allowing the model to react more strongly to recent changes.

γ (gamma) is the smoothing parameter for the seasonal component. It controls the weight placed on the seasonal component when updating it. A smaller γ makes the model less responsive to short-term seasonal changes, while a larger γ gives more weight to the most recent season, making the model more responsive to seasonal patterns.

These smoothing parameters (α, β, and γ) are estimated from historical data using optimization techniques to achieve the best fit for the specific time series being analyzed.

5.9 Ethics approval

The study has permission from the Vietnam National Institute of Hygiene and Epidemiology (NIHE) for using data for research purposes and an ethics approval from ANU HREC protocol 2023/159.

5.10 Results

There were a total of 100,071 reported measles cases over the 20 year period from 2003 to 2022 nationwide, all 63 provinces and cities recorded cases.

5.10.1 Temporal and Spatial Trend of Measles cases in Vietnam, 2003-2022

The number of measles cases in Vietnam fluctuated significantly from 2003 to 2022, with major outbreaks occurring in the years 2009-2011, 2014, and 2018. The number of cases peaked in 2014, with the highest number was 9,121 cases in April. Overall, measles cases were predominantly recorded during the early months of the year (Figure 5.5).

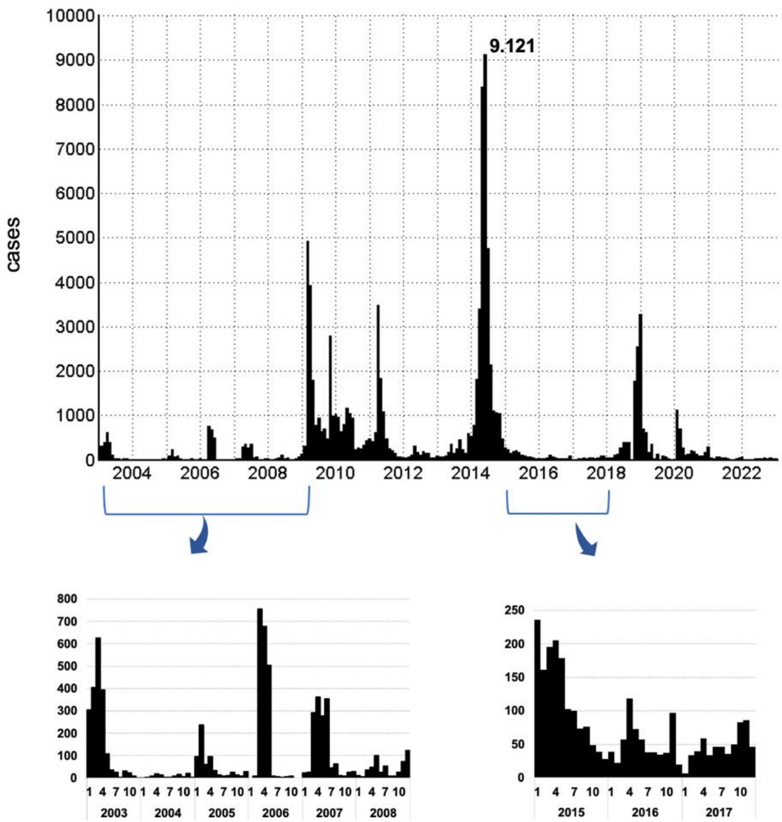


Figure 5.5. Incidence of measles by month of the year in Vietnam, 2003-2022

The majority of measles cases were reported in the 28 northern provinces and the 20 southern provinces, with the highest number of cases in the peak month of 2014 reaching approximately 4.500 cases in each region. However, while measles cases in the Northern region appeared sporadically over the years, measles cases in the Southern region mainly occurred during the mentioned large outbreaks. The number of cases in the Central region accounted for only 5%

of the cases in the two regions mentioned above, and the number of cases in the four Highlands provinces was much lower, with a proportional increase during national outbreaks in general (Figure 5.6).

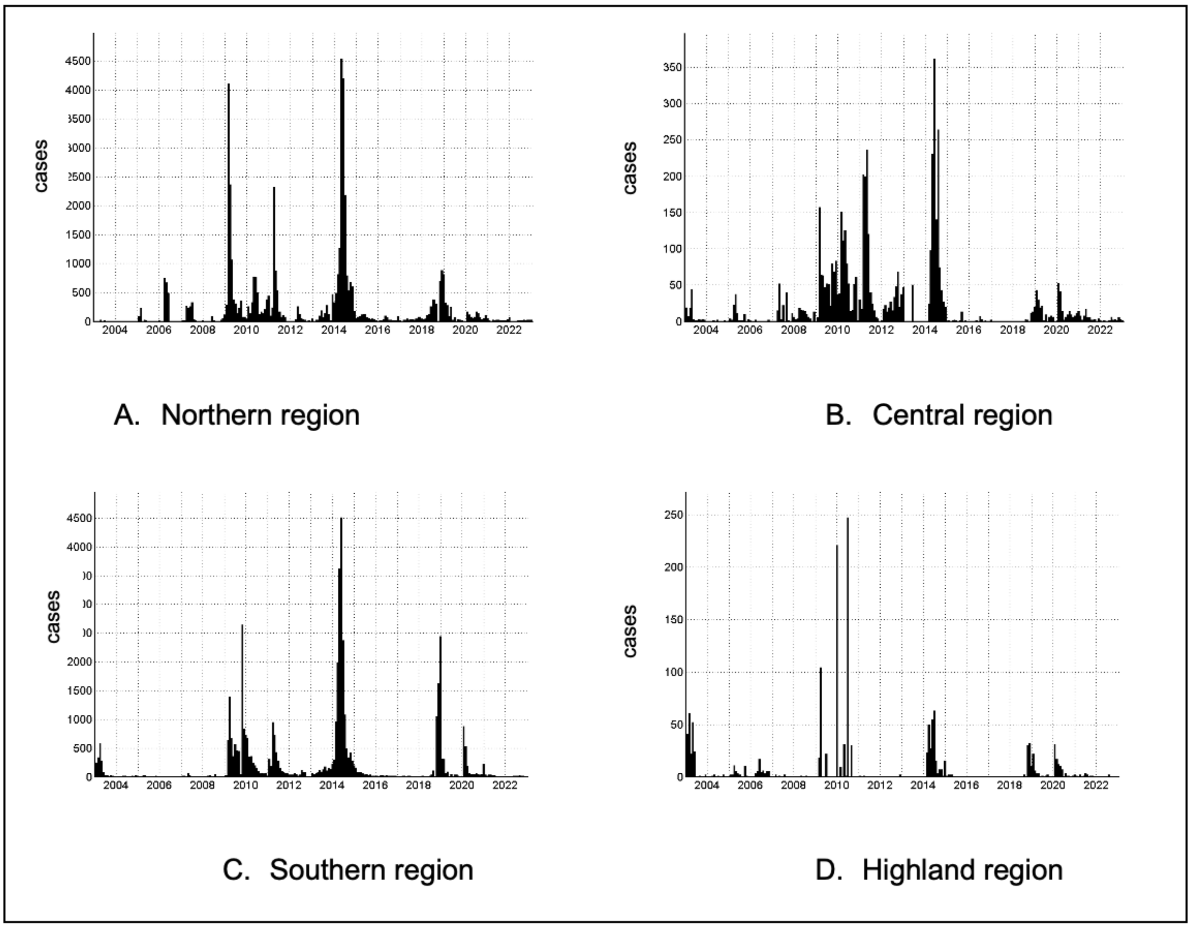


Figure 5.6. Incidence of measles by geographic region, by month of the year in Vietnam, 2003-2022

The logarithmic transformation has been applied to the data using the logarithm function before plotting the box plot below (Figure 5.7), aiming to reduce the differences between values in the original dataset. The largest interquartile range (IQR) is observed in the early months and the last two months of the year, indicating that there are substantial differences between the data points in terms of their magnitudes. Months from March to June have the highest medians of the year, with April standing out as the peak. April also has the shortest IQR, highlighting the concentration of data and reinforcing the degree of measles cases occurring primarily in April, despite one outlier at the upper extreme.

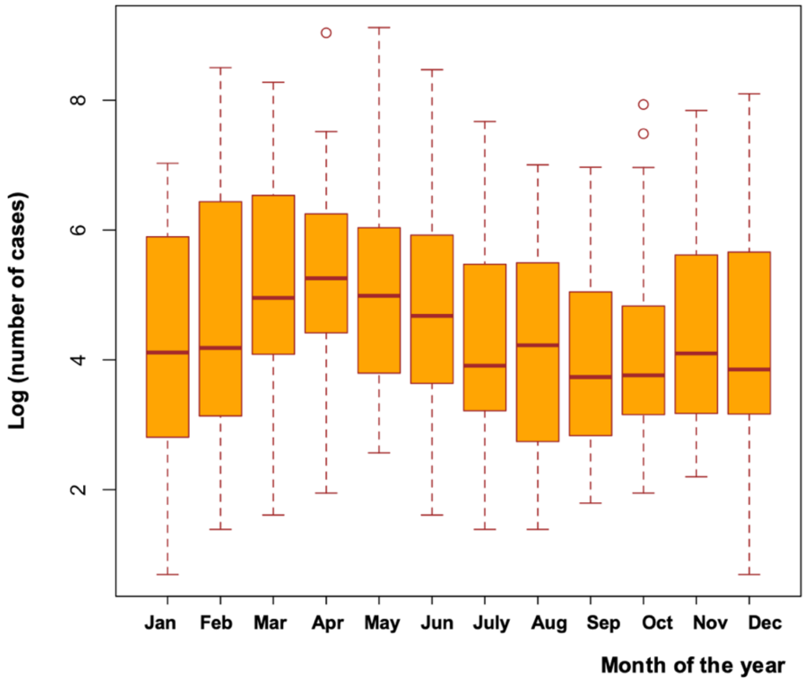


Figure 5.7. Box plot of the incidence of measles by month of the year in Vietnam, 2003-2022

The peak incidence typically happens annually during the months of February to May, which is the transitional period between spring and summer or the dried season in Vietnam. A second outbreak peak may occur around the last three months of the year (Figure 5.8).

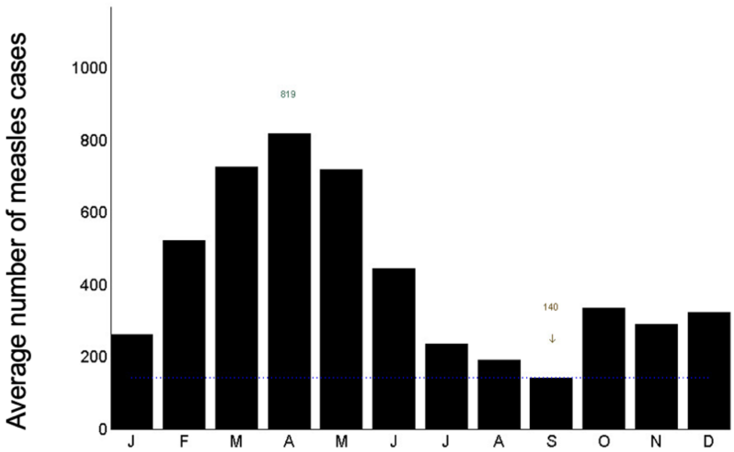


Figure 5.8. Measles incidence for each month of an average year in Vietnam, 2003-2022.

In general, all four geographical regions primarily reported measles cases in the early months of the year. The Northern, Central, and Southern regions all experienced the main outbreak peak in April each year, while the Highland region's peak occurs in June. The secondary outbreak peak is more pronounced in the Southern region, with an average of over 150 cases in the last three months of the year (Figure 5.9).

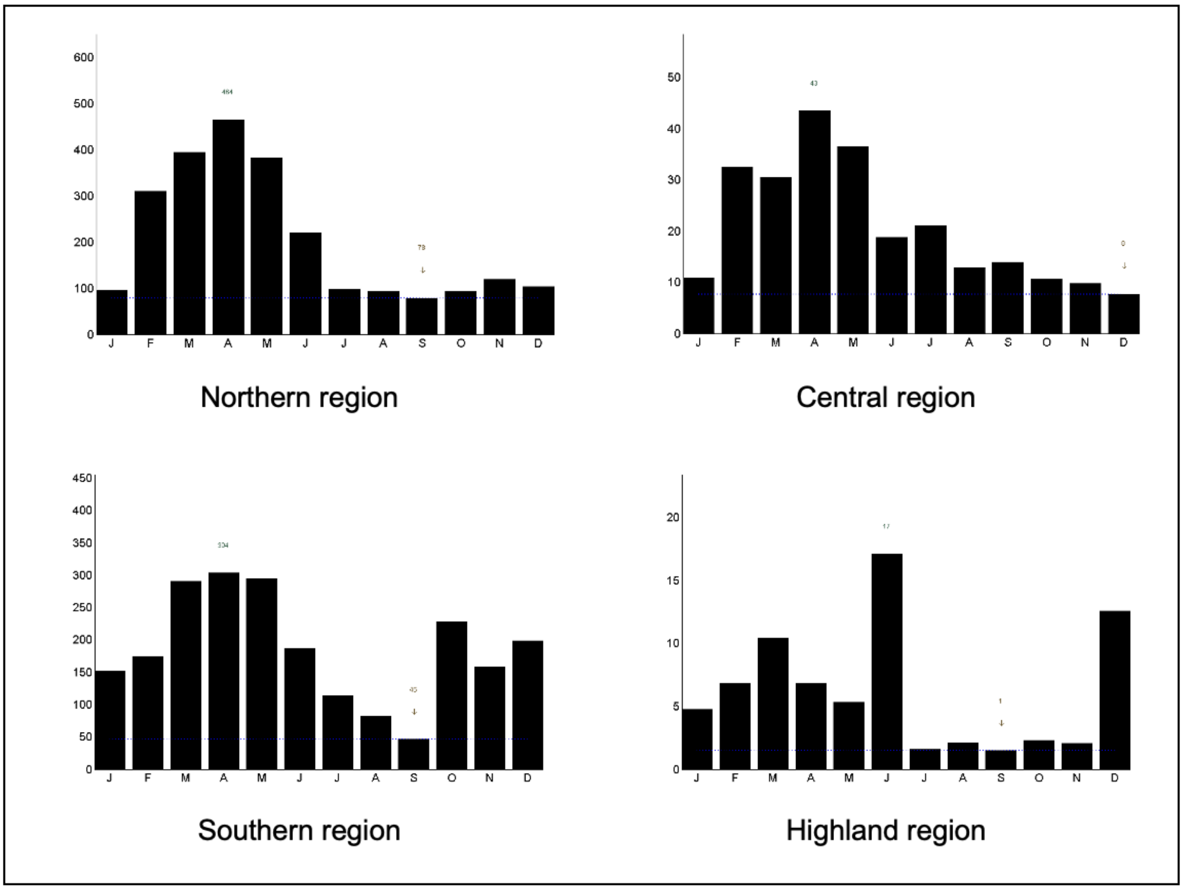


Figure 5.9. Measles incidence for each month of an average year by geographic region in Vietnam, 2003-2022.

Figure 5.10 shows the timing of primary peaks, derived from the measles case time series within the period from 2003 to 2022 for each province in relation to the latitude of their central cities. In general, the patterns of peak measles occurrences in this tropical nation closely corresponded to the dry season in the whole country or in the north, it was spring-summer. However, in the northern half of the country, measles outbreaks were concentrated in the months of March to May, while in the southern half, outbreaks occurred approximately one month earlier, starting from February to April.

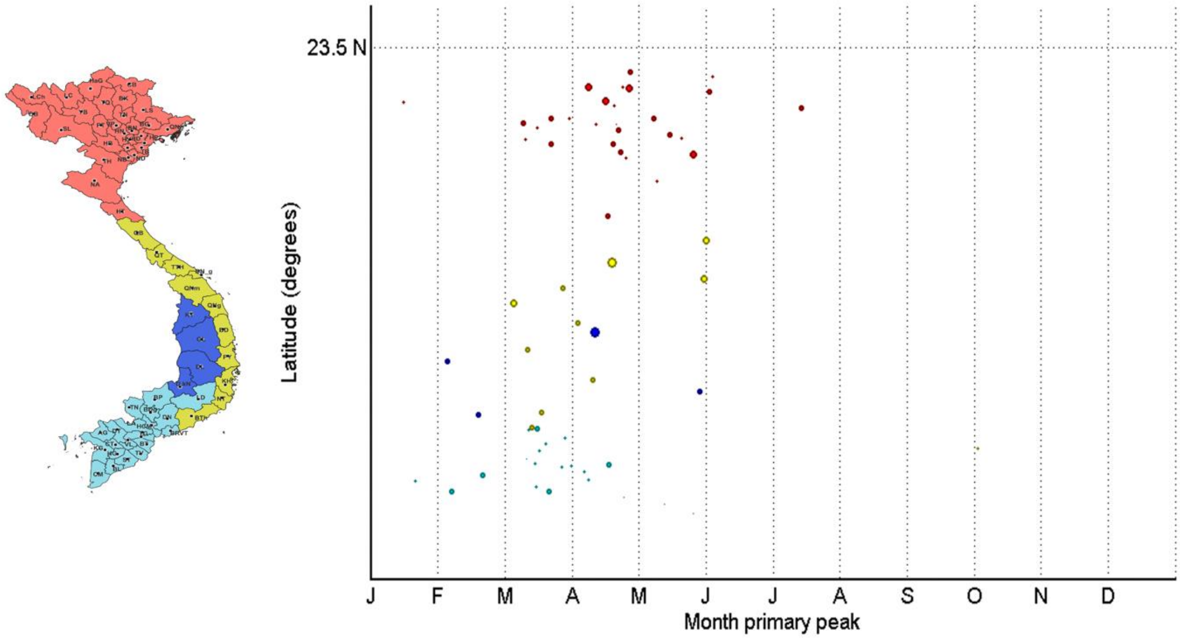


Figure 5.10. Timing of the primary peak of measles detection (2003–2022), by province, against the latitudinal position of the capital city.

The data underwent square root transformation and detrending using polynomial methods to minimize the impact of noise on the actual model. The point sizes represent the magnitude of measles seasonality, while various colors are utilized to differentiate provinces within the four regions.

Figure 5.11 and 5.12 provides a comprehensive depiction of the measles notification time series spanning from 2003 to 2022, organized by month and categorized according to distinct provincial patterns. The data is presented in a grid layout, with provinces aligned in rows based on the latitudinal position of their population centroids, commencing with the northernmost province at the top and proceeding southward. Each month's notification counts are visually represented using a color gradient, transitioning from dark blue (indicative of fewer notifications) to dark red (reflecting a higher volume of notifications). Instances of zero notifications are denoted in black.

This outcomes highlight the patterns in measles occurrences and, more importantly, the spatial distribution of outbreaks across Vietnam. It is worth noting that the distribution of measles cases varies significantly by region. During the outbreak period from 2009 to 2011, a majority of cases were concentrated in the Central and Highland regions, followed by the North region. In contrast, the 2014 outbreak exhibited a more widespread distribution across the country, with a stronger impact in the Southern regions.Notably, the Southeastern region, which includes the Southeastern provinces, recorded the highest number of cases during the late 2018 to early 2019 outbreak.

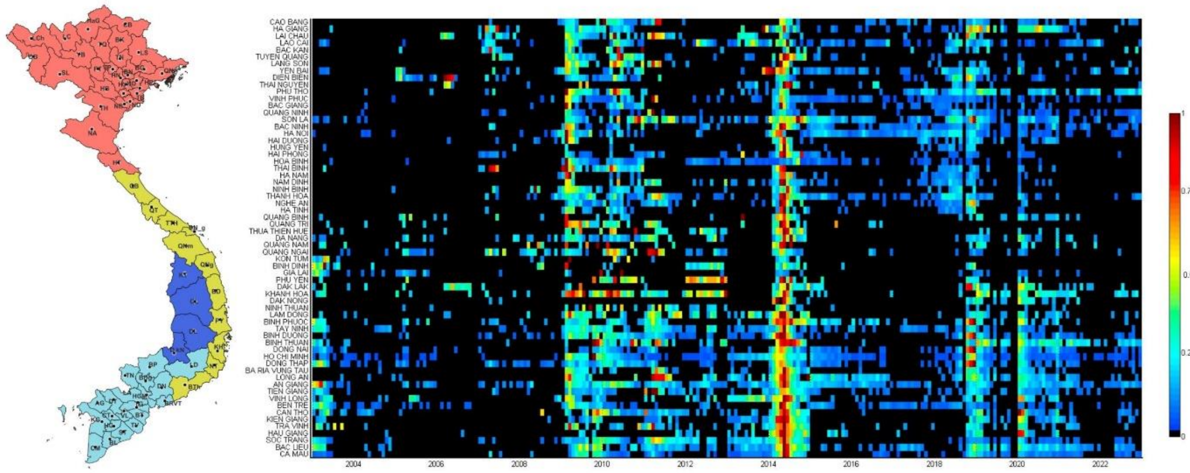


Figure 5.11. Heatmaps of measles epidemiological data by Vietnamese province by latitude, 2003-2022.

In Figure 5.11, the highest peak, corresponding to a value of 1 on the scale (observed in Ho Chi Minh City with 2.231 cases occurring in October 2009, this city belongs to the South region), is highlighted in dark red. Similarly, in Figure 5.12 for the remaining regions, in the Northern region, it was Lao Cai with 749 cases in June 2014; in the Central region, it was Quang Ngai Province with 178 cases in April 2011, and in the Central Highlands, the lowest number of cases was 247 in Gia Lai Province in June 2010. Furthermore, some other provinces stand out with a significant number of reported cases, such as Vinh Phuc and Cao Bang (in the Northern region), Da Nang and Binh Thuan (in the Central region), Dak Nong (in the Central Highlands), and Ca Mau, Soc Trang, and Binh Duong (in the Southern region).

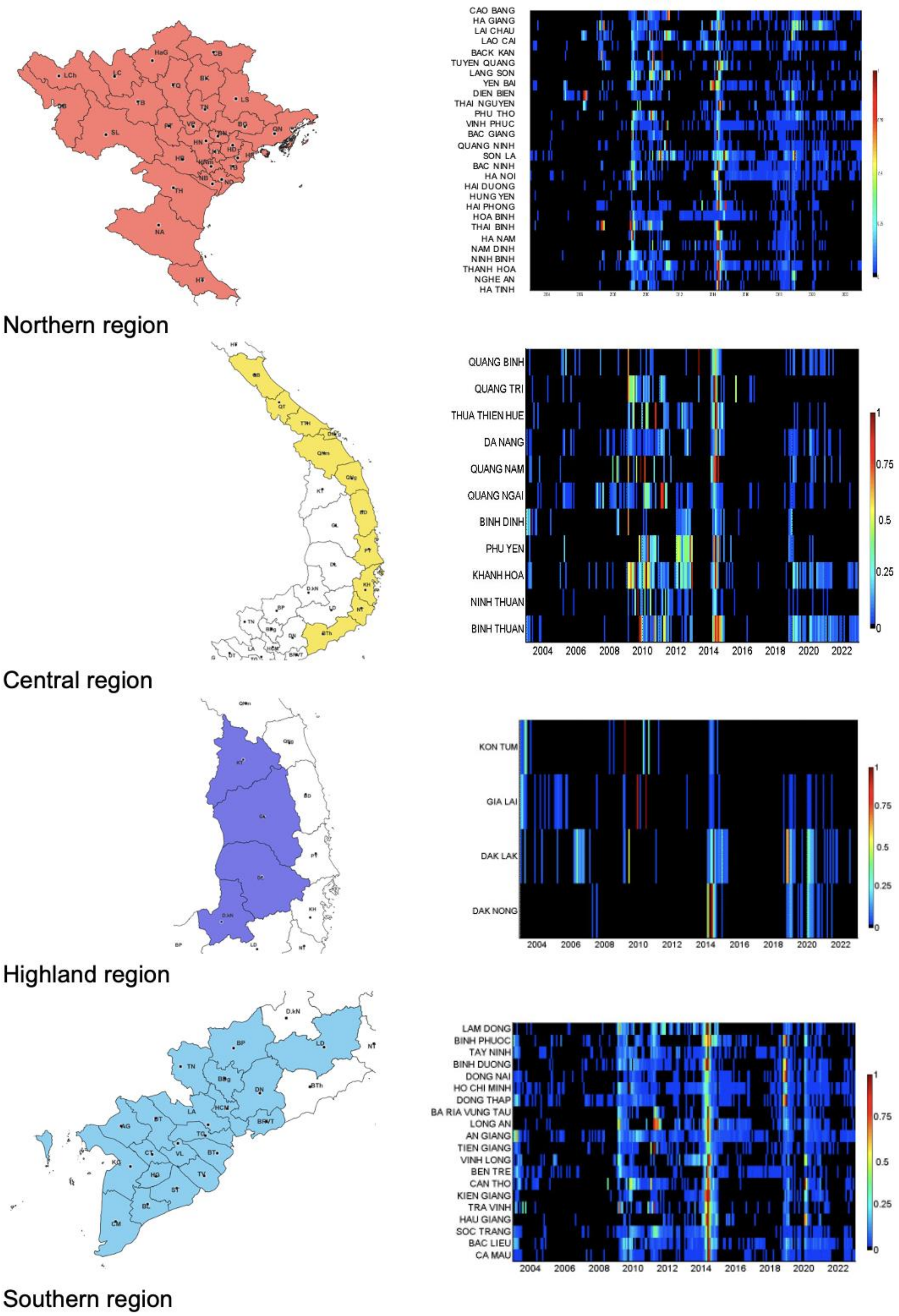


Figure 5.12. Heatmaps of measles epidemiological data by Vietnamese province by latitude, by geographic region, 2003-2022.

5.10.2 Analyzing components in the 20-year measles time series data in Vietnam

Figure 5.13 decomposes the "observed" component into three parts: trend, seasonal, and random. The trend fluctuates with peaks and shifts as listed in Figure 5.5 above. Within each year, the number of cases shows seasonal variations, with a primary peak at the beginning of the year and a secondary peak at the year's end. The random component appears to share similarities with the "observed" part.

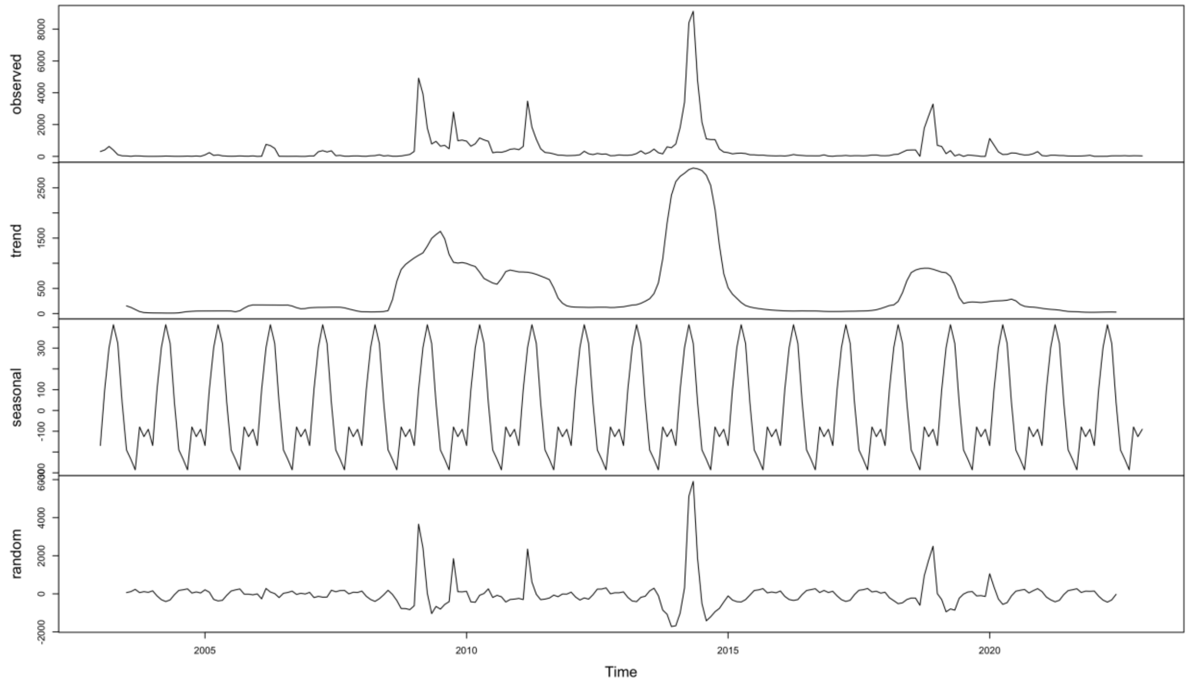


Figure 5.13. Decomposition of additive time series of measles in Vietnam, 2003-2022

The time series in light blue represents 20 years of raw data, whereas the overlapped red curve represents the model trend and seasonality (Figure 5.14). The standardized wave has a bimodal periodic annual peak, the primary peak was in April, and the secondary peak was in October.

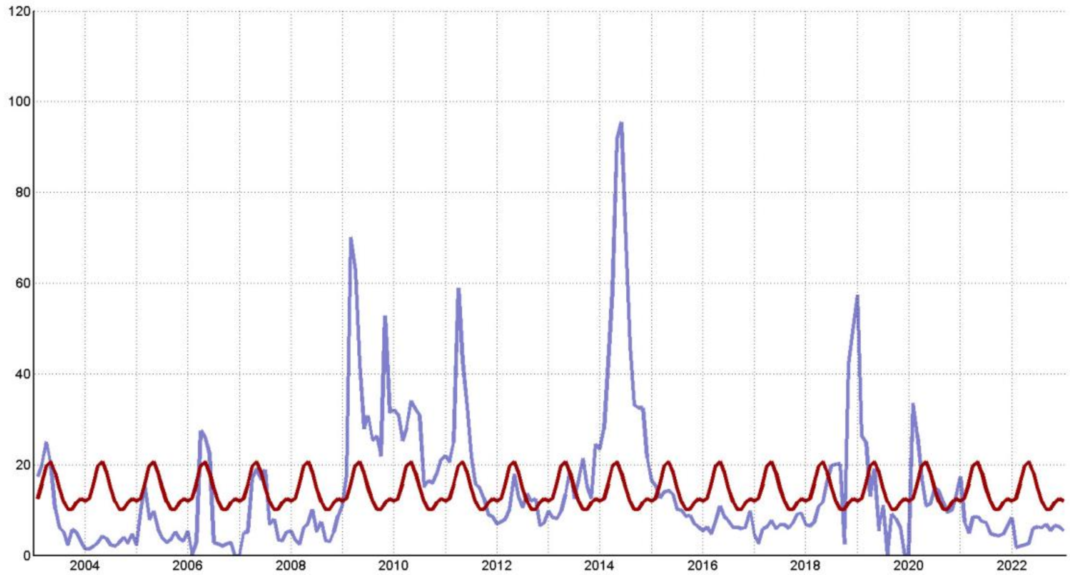
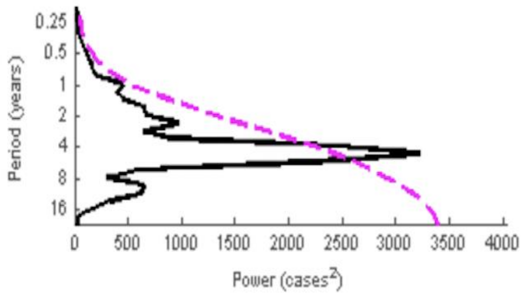


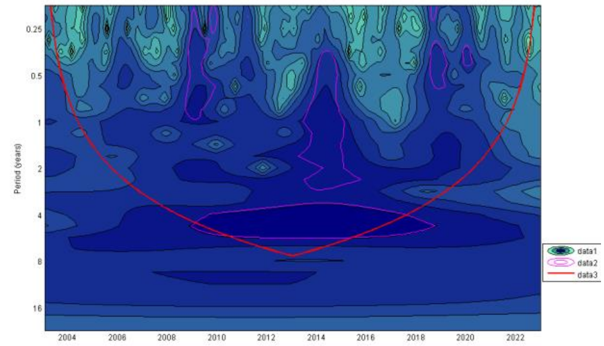
Figure 5.14. Monthly time series of measles cases in Vietnam, 2003-2022

(The light blue line represents the observed case counts, the red line shows the fitted seasonal - trend component generated using the EPIPOI tool.)

Figure 5.15 and 5.16 illustrate the historical trends of the measles time series in Vietnam and regional levels based on Wavelet analysis, depicts periodic patterns and temporal variations. Colors show the distribution of measles cases. Darker blue colors represent a stronger frequency.

Twenty years of data show that from 2009 to 2019, an epidemic occurs once in a period of 4 to 5 years. (The dark blue part inside the pink area shows the periodicity with statistical significance at the level of 4-5 years.) Additionally, it can be seen that a one-year epidemic period appears sporadically in 2009, 2014, and 2019, but it is not statistically significant.





The dashed pink line shows the 95% confidence level.

Data1 - Wavelet Spectrum: Distribution of power across scales and time positions.
Data2 - Areas of high recurrence in the Wavelet spectrum are considered at a 95% confidence level.
Data3 - The cone of influence (COI)

Figure 5.15. The periodicity of measles in Vietnam 2003-2022

The data from figure 5.16 show that the appearance cycle of measles, which is 4-5 years, is statistically significant in the Northern and Southern regions. However, the Central region records a shorter cycle of 1-2 years. The Central Highlands region does show a 4-5 year cycle, but the dataset is not large enough to establish statistical significance. There is only statistical significance at the semi-annual cycle level, meaning sporadic occurrences each year.

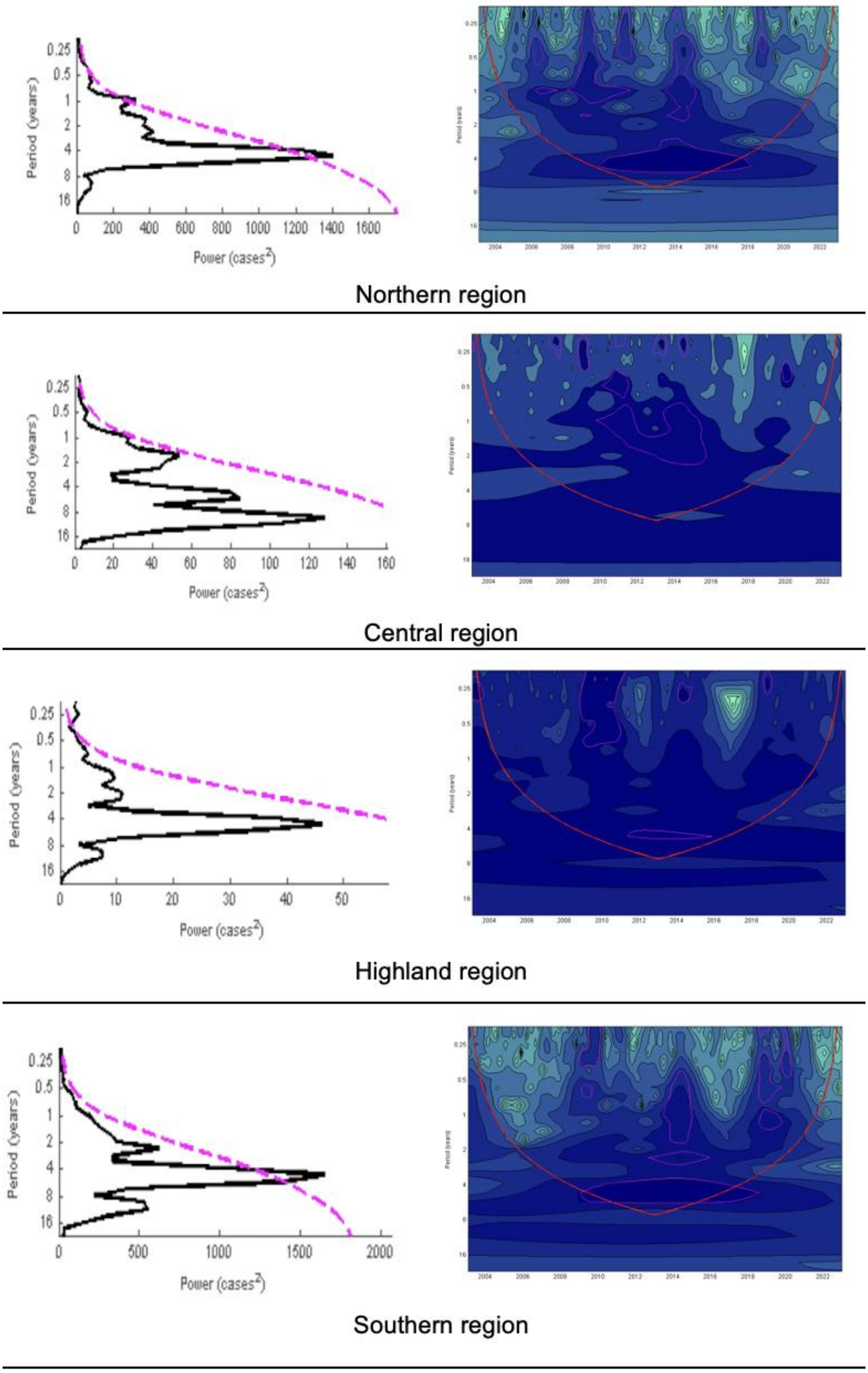


Figure 5.16. The periodicity of measles by geographic region in Vietnam 2003-2022

5.10.3 Forecasting the measles epidemic trends in the next 5 years by the Holt-Winters exponential smoothing method

Figure 5.17 illustrates the application of Holt-Winters exponential smoothing to analyze a historical time series dataset spanning from 2003 to 2022. The purpose of this analysis is to evaluate the effectiveness of this method on the existing dataset, assess its ability to capture trends and seasonal patterns in historical data. Consequently, based on this effectiveness, the performance of this method can be evaluated for future forecasts, providing insights into future data patterns (as shown in Figure 5.18).

Regarding the parameters in Figure 5.17, an α value of 0.6605 signifies that roughly 66.05% of the weight is given to the most recent observation when computing the forecast. This value strikes a balance between responsiveness to recent data and stability in Holt-Winters exponential smoothing analysis of the time series data. The presence of a non-zero β value implies that the model acknowledges the existence of a trend within the dataset, where a smaller β (β = 0.0078) indicates a gradual change in the trend component over time, considering only a small fraction of the latest trend. The presence of an "additive seasonal component" suggests that seasonal fluctuations are consistently added to the overall level of the data.

In summary, the chart demonstrates that the forecasted values align closely with the actual observations. The results show a good balance between being responsive to short-term fluctuations, trends, and relatively stable seasonality, indicating the efficacy of the forecasting model.

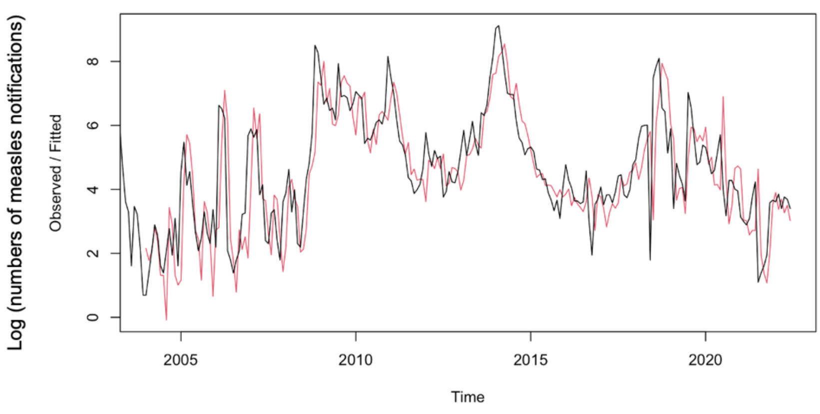


Figure 5.17. Applying Holt-Winters exponential smoothing method with trend and additive seasonal component for the historical time series data of measles from 2003 to 2022 in Vietnam.

The smoothing parameters are α=0.6605, β=0.0078, γ=0.5397.

Figure 5.18 presents the forecasted model for measles cases in Vietnam. Overall, the measles trend in Vietnam is projected to decrease over the next 5 years while still maintaining its seasonal patterns. The highest Point Forecast occurs in January 2023, with a value of 4.069607 and an 80% confidence interval ranging from 1.19955344 to 6.939661 and a 90% confidence interval from -0.3197612 to 8.458975. The lowest Point Forecast is expected in June 2027, with a value of 1.423796, along with an 80% confidence interval ranging from -8.17100765 to 11.018601 and a 90% confidence interval from -13.2501901 to 16.097783.

To obtain the actual values (non-logarithmic), a reverse operation is performed, resulting in forecasted values fluctuating within the range of 27 to 11.738 cases.

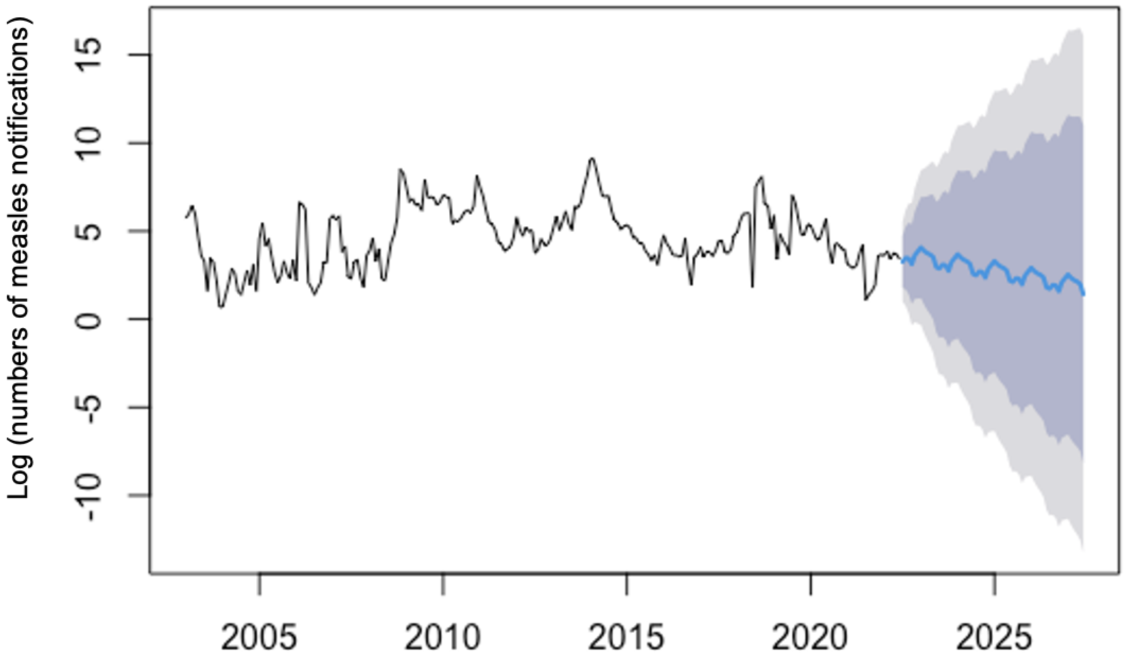


Figure 5.18. Forecasting measles cases in Vietnam for the next 5 years (2023-2027) using the Holt-Winters exponential smoothing method.

The forecasted values are shown in blue, with the shaded areas in dark gray and light gray corresponding to 80% and 95% confidence intervals, respectively.

5.11 Discussion

The study's findings illuminate the seasonal and geographical patterns of measles in Vietnam. The observed data from 2003 to 2022 reveal that measles outbreaks have been relatively frequent in Vietnam, with major outbreaks occurring in the years 2009-2011, 2014, and 2018. This cyclical pattern, with large-scale outbreaks approximately every 4-5 years, aligns with domestic reports [28]. However, the recurring outbreaks within this cycle indicate that the current intervention measures have not been effectively controlled measles in Vietnam. It is necessary to maintain vaccination efforts, enhance community immunity, and closely manage vaccination programs to narrow the immunity gap.

The study highlights the strong seasonal epidemiological characteristics of measles in Vietnam. The disease consistently peaks during the transition from spring to summer, roughly between February and Jun. This coincides with nationwide festivals, especially the Lunar New Year, which can attract large crowds and contribute to the rapid transmission of measles, one of the most highly contagious infectious diseases with the highest reproduction number (R0) [29], if an outbreak occurs around these festive times. This seasonality is consistent with the characteristics of measles in tropical countries like Vietnam [30]. The measles virus can thrive in certain environmental conditions, and the dry season might create an environment conducive to the spread of the disease [31].

Moreover, the study points out that larger cities like Hanoi, Ho Chi Minh City, and provinces with numerous industrial zones are at a higher risk. These urban areas have high population density, frequent human mobility, and periodic interruptions in vaccination services. These factors create a favorable environment for the spread of measles when outbreaks occur in vulnerable or under-immunized communities.

It is crucial to acknowledge the potential impact of the COVID-19 pandemic on measles patterns. Disruptions to routine vaccination programs and healthcare access during the pandemic might have indirectly affected measles transmission. While the national measles vaccination rate dropped below 90% during the COVID-19 pandemic [6], this reduction results from various factors, including vaccine supply during the pandemic, public hesitancy, and more. The interplay of these factors requires further investigation. On a positive note, measures such as social distancing, mask-wearing, and community awareness during the COVID-19 pandemic indirectly contributed to reducing measles cases and other infectious diseases. However, the significant reduction in measles cases during the COVID-19 period (2019-2022) may need to be taken into account when considering the results of the Holt-Winters Exponential Smoothing forecasting method applied in this study, as this method is a short-term forecasting approach based on the most recent observations. In addition, the decline in MCV1 and MCV2 coverage during the pandemic suggests a reduction in herd immunity, which increases the risk of a resurgence once infection-control measures are relaxed. The unusually low incidence observed from 2019 to 2022 may therefore mask an accumulation of susceptible individuals, underscoring the importance of interpreting forecasts with caution and prioritising catch-up vaccination efforts in the post-pandemic period.

Regarding seasonality and future trends, the model indicates a potential decline in measles cases, yet the seasonal pattern persists. The relatively wide confidence intervals, especially the 90% confidence interval, reflect the uncertainty in the prediction. This projection should be interpreted cautiously in light of possible shifts in measles epidemiology after the COVID-19 pandemic. Changes in health-seeking behaviors, heightened awareness of infection prevention, and temporary disruptions to immunization services may all have influenced measles transmission, underscoring the importance of viewing forecasts within the broader post-pandemic context. Further studies are needed to provide a more accurate assessment.

When a forecasting model overfits with historical data, it means the model fits the historical data too closely, capturing noise and random fluctuations rather than the true underlying patterns. This leads to excellent historical performance but poor generalization to new data [32]. In this study, the "random" component's similarity to the "observed" part might indicate inherent data noise or complex, non-linear relationships that the model's trend and seasonality components cannot fully explain.

5.12 Limitations

One limitation of this study is the absence of weather data, which could have provided valuable insights into the influence of climate on measles outbreaks. In addition, reliance on surveillance data introduces potential biases from underreporting, reporting delays, and changes in case definitions or healthcare-seeking behavior over time. The Holt-Winters exponential smoothing method assumes that historical seasonal and trend patterns will remain stable, which may not reflect real-world dynamics influenced by vaccination campaigns, outbreak responses, or shifts in population immunity. This limitation is particularly relevant when new disruptive factors arise, such as the COVID-19 pandemic, substantial declines in vaccination coverage, or temporary reductions in population mixing and travel. The forecasting model also did not explicitly incorporate post-pandemic changes, such as variations in case reporting, vaccination uptake, or community practices related to isolation and infection control, which may have affected the observed data. Another limitation lies in the use of two different data sources - Yearbook and NEDSS - with differences in reliability and consistency. Yearbook data are paper-based and cross-verified, while NEDSS, as an electronic reporting system, is subject to updates, underreporting, or reporting delays. For 2019–2022, NEDSS was the only feasible source due to COVID-19 restrictions, but these aggregated monthly counts may still contain discrepancies compared with Yearbook data. Consequently, the wide confidence intervals and lack of exogenous variables (e.g., vaccine coverage, demographics, case importation) limit the model’s predictive accuracy, underscoring the need for future studies that integrate these evolving factors. Therefore, the forecasts generated in this study should be interpreted as indicative rather than definitive, serving primarily as a reference to highlight possible trends rather than precise predictions for policy and planning.

5.13 Recommendation

Based on the findings and discussions presented in the study regarding measles patterns in Vietnam, we suggest some recommendations as follows:

Strengthen and expand Vaccination Efforts: Ensuring high vaccination coverage is crucial to prevent measles outbreaks. Public health authorities should not only maintain but urgently review and intensify vaccination strategies to bring MCV1 and MCV2 coverage well above 90%. This requires large-scale catch-up campaigns, targeted vaccination of under-immunized populations, and inclusion of occupational groups in close contact with vulnerable individuals (such as healthcare workers, educators, and childcare staff).

Close Monitoring and Rapid Response Surveillance: Robust surveillance systems must be maintained and strengthened to enable early detection of outbreaks. Timely reporting and response are essential, including rapid case investigation, isolation, contact tracing, and swift implementation of additional vaccination campaigns.

Adapt to Seasonality: Recognize and prepare for the strong seasonality of measles in Vietnam, with peaks during spring and early summer. Vaccination efforts and preparedness activities should be intensified in the months preceding these peaks, and especially around national holidays or festivals that drive large-scale population mixing.

Urban Areas and Industrial Zones: Larger cities and industrial zones remain hotpots due to high population density and frequent human mobility**.** Focused vaccination, healthcare accessibility, and outbreak preparedness in these areas should be prioritized to prevent widespread transmission.

Preparedness for Institutional Outbreaks: Schools, kindergartens, hospitals, and other institutional settings require specific contingency plans for outbreak management, including vaccination verification, rapid isolation procedures, and communication strategies.

Advance Research and Evidence Use: Continued research is needed to deepen understanding of measles outbreak dynamics in Vietnam, integrating vaccination coverage data, mobility patterns, weather variability, and post-pandemic shifts in immunity. Evidence from such studies should directly inform adaptive public health interventions.

Public Health Call to Action: Measles continues to pose a substantial epidemic risk in Vietnam, especially in the post-COVID-19 period. Aggressive and immediate public health action is essential—particularly in vaccination, epidemic preparedness, outbreak management, and risk communication—to avert a potential measles emergency in the coming years.

5.14 Conclusion

In conclusion, this study offers valuable insights into the seasonal and geographical patterns of measles in Vietnam. The annual cyclical nature of measles outbreaks during spring and summer, with a peak from February to June, remains consistent. This yearly cycle tends to occur about 1 month earlier in the southern region compared to the northern region. Measles is frequently observed in densely populated major cities. The previously established 4-5 year cyclical pattern of major outbreaks has been validated. However, the forecasting model for the next 5 years indicates a declining trend, underscoring the challenges of prediction and the need to integrate additional factors such as vaccination coverage, population mobility, and post-pandemic changes. This study emphasizes the ongoing importance of comprehensive surveillance, maintaining vigilance, and timely interventions to address the evolving landscape of measles in Vietnam.

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Chapter 6. Other MAE requirements

Lay audience report: “The Risk of Resurgence in Vaccine Preventable Infections after the easing of COVID-19 control”

Lesson from the field: “Mapping an outbreak: Plotting cases with specified spatial coordinates to QGIS”

Teaching experience: “Guide to Using QGIS Software for Drawing Infectious Disease Epidemiology Maps”

List of Abbreviations – Chapter 6

MAE	Master of Applied Epidemiology Program
COVID-19	Coronavirus Disease 2019
DPT	Diphtheria-Pertussis-Tetanus
EPI	Expanded Programme on Immunization
QGIS	Quantum Geographic Information System

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6.1 Lay audience report

I authored the report, and it underwent editing by Dr. Pham Quang Thai, my field supervisor. The report is accessible on the official website of the Vietnam Ministry of Health, specifically on their health and lifestyle section known as "Sức Khoẻ & Đời Sống." This publication is managed by the Vietnam Ministry of Health's Department of Health Communication and Rewards. It is provided to the general public in Vietnam free of charge, with the aim of advancing health education and enhancing health literacy.

Citation:

Huyen Nguyen, Pham Quang Thai (2022) "***The Risk of Resurgence in Vaccine Preventable Infections after the easing of COVID-19 control***" (Original title in Vietnamese: "*Nguy cơ tái bùng phát bệnh có thể dự phòng bằng vaccine*"), Suc Khoe & Doi Song Newspaper - Official press representatives of Vietnam Ministry of Health, 28 June 2022. Available at: https://suckhoedoisong.vn/nguy-co-tai-bung-phat-benh-co-the-du-phong-bang-vaccine-16922062808144373.htm

6.1.1 Web version (Vietnamese)

Available at: https://suckhoedoisong.vn/nguy-co-tai-bung-phat-benh-co-the-du-phong-bang-vaccine-16922062808144373.htm

Nguy cơ tái bùng phát bệnh có thể dự phòng bằng vaccine

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SKĐS - Phần lớn các trường hợp mắc các bệnh nhiễm trùng hoặc liên quan tới nhiễm trùng trong đó khá nhiều là các bệnh có thể dự phòng được bằng vaccine. Đây là một dấu hiệu chỉ điểm rõ nhất về nguy cơ gia tăng dịch bệnh sau khi các hạn chế để phòng chống dịch COVID-19 được nới lỏng.

Mùa hè là thời điểm tăng cao về hoạt động du lịch và nghỉ dưỡng, đặc biệt đối với các gia đình có học sinh đang trong giai đoạn nghỉ hè.

Việc tập trung đông người và giao lưu nhiều vùng miền tại các điểm du lịch, sân bay, bến xe, nhà ga… tiềm ẩn nhiều nguy cơ lây lan dịch bệnh như COVID-19 và đặc biệt là các bệnh có thể phòng ngừa bằng vaccine như sởi, ho gà, bạch hầu, viêm não nhật bản… do những đợt ngưng hoặc hoãn tiêm chủng vaccine trong đại dịch vừa qua.

Dịch COVID-19 và những tác động tới chương trình tiêm chủng

Dịch COVID-19 đã và đang gây ra những tác động to lớn đến mọi mặt của đời sống từ sức khoẻ, kinh tế đến chính trị của toàn xã hội. Mặc dù đến thời điểm hiện tại đại dịch đã được khống chế và cuộc sống dần trở lại bình thường, tuy nhiên COVID-19 vẫn là mối đe dọa khó lường bởi các tác động trực tiếp và gián tiếp của nó.

Sau những nỗ lực kiểm soát dịch COVID-19, chương trình TCMR đã thúc đẩy việc tiêm chủng và khẩn trương tiêm bù, tiêm vét cho các đối tượng bị trễ lịch. Ảnh minh hoạ

Việt Nam trải qua 4 đợt dịch COVID-19 lớn và nhiều lần thực hiện giãn cách toàn xã hội hoặc giãn cách cục bộ để phòng chống lây lan dịch. Chương trình tiêm chủng mở rộng (TCMR) và các dịch vụ tiêm chủng tư nhân đều phải tạm dừng để thực thi chiến lược đối phó với đại dịch dẫn đến nhiều trẻ em bị trễ lịch tiêm chủng.

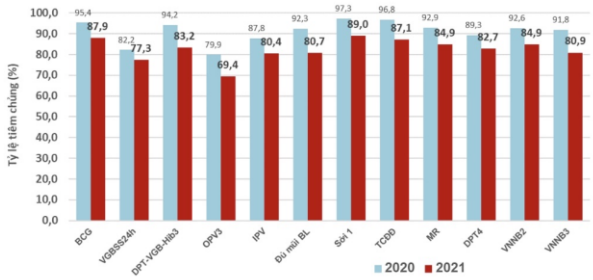
Sau những nỗ lực kiểm soát dịch COVID-19, chương trình TCMR đã thúc đẩy việc tiêm chủng và khẩn trương tiêm bù, tiêm vét cho các đối tượng bị trễ lịch. Tuy nhiên, đâu đó vẫn còn phần đông phụ huynh chưa dám cho con đi tiêm chủng trở lại do lo lắng nguy cơ lây nhiễm dịch bệnh.

Bên cạnh đó, việc tiếp cận vaccine sau đại dịch càng trở nên khó khăn hơn ở nhóm trẻ em đồng bào thiểu số, trẻ em có hoàn cảnh khó khăn, dân trí thấp, sinh sống ở vùng sâu, vùng xa, trẻ theo cha mẹ đi làm ăn xa và ở nhóm trẻ chịu gánh nặng nhiễm COVID-19 cao nhất.

Điều này dẫn đến ngày càng tích lũy lớn số trẻ em không tiêm, tiêm trễ gây nên khoảng trống miễn dịch gia tăng tại một số địa bàn. Đây là nguy cơ tiềm ẩn của các đợt bùng phát dịch bệnh trong tương lai.

Theo báo cáo sơ kết công tác TCMR năm 2021 của Dự án TCMR Quốc gia, hầu hết tỷ lệ tiêm chủng các vaccine, ngoại trừ DPT4, trong TCMR không đạt chỉ tiêu kế hoạch năm và thấp hơn năm 2020 cho thấy ảnh hưởng lớn chưa từng có của dịch COVID-19 đến triển khai công tác TCMR.

Xét về quy mô tuyến huyện, số huyện có tỷ lệ bao phủ tiêm chủng ≥90% giảm thấp nhất trong vòng 6 năm qua, đồng thời với số huyện có tỷ lệ Tiêm chủng đầy đủ <80% tăng cao nhất trong vòng 6 năm qua cho thấy ảnh hưởng của dịch đến công tác TCMR trên diện rộng.



Tỷ lệ tiêm chủng các vắc xin trong Chương trình tiêm chủng mở rộng toàn quốc năm 2020-2021 (Nguồn: Báo cáo tổng kết 2021 Dự án TCMR Quốc gia)

Nguy cơ gia tăng dịch bệnh có vaccine phòng ngừa trong thời gian tới

Vài tuần trở lại đây, theo báo cáo thống kê từ BV Nhi Trung ương, số lượng trường hợp đến khám tại bệnh viện đã đạt mức khoảng 6 ngàn mỗi ngày, gấp 1,5 lần so với thời kỳ cao điểm trước khi COVID-19 có mặt tại Việt Nam.

Phần lớn các trường hợp mắc các bệnh nhiễm trùng hoặc liên quan tới nhiễm trùng trong đó khá nhiều là các bệnh có thể dự phòng được bằng vaccine. Đây là một dấu hiệu chỉ điểm rõ nhất về nguy cơ gia tăng dịch bệnh sau khi các hạn chế để phòng chống dịch COVID-19 được nới lỏng.

Sự sụt giảm tỷ lệ tiêm chủng hay tiêm trễ lịch các loại vaccine kể trên không chỉ ở Việt Nam mà xét trên bình diện quốc tế, là nguy cơ bùng phát các bệnh nguy hiểm như sởi, ho gà là những bệnh nguy hiểm, dễ lây lan và có hệ số lây nhiễm cơ bản (R0) cao hơn so với COVID-19.

Virus sởi lây nhiễm trong không khí ở mức độ dễ dàng hơn COVID-19 và cũng tồn tại và lây nhiễm từ các bề mặt đồ vật bị nhiễm bệnh. Bệnh thâm chí có thể lây nhiễm trước 4 ngày so với ngày khởi phát. Một đứa trẻ mắc sởi có thể lây nhiễm cho khoảng 90% người khác nếu họ chưa có miễn dịch do nhiễm tự nhiên hoặc chưa được tiêm ngừa.

Tại Việt Nam, dù đã có hơn 30 năm tiêm chủng thành công nhưng một số vụ dịch sởi lớn trong những năm gần đây, điển hình là vụ dịch năm 2014, toàn quốc ghi nhận hơn 30.000 trường hợp sốt phát ban nghi sởi, trong đó hơn 5.800 trường hợp xác định phòng thí nghiệm, 147 trường hợp tử vong có liên quan bệnh sởi.

- **Tầm quan trọng của tiêm nhắc phòng bạch hầu, ho gà, uốn ván, bại liệt cho trẻ 4-6 tuổi**
- **Cục trưởng Cục Y tế dự phòng nói gì về "Ký cam kết tiêm vaccine COVID-19"?**
- **Miễn dịch ở người đã tiêm vaccine liều cơ bản và mắc COVID-19 sẽ suy giảm: Cần thiết tiêm mũi 3, mũi 4**
- **Vì sao Bộ Y tế vẫn đề xuất COVID-19 là bệnh truyền nhiễm nhóm A, chưa là bệnh lưu hành?**

Năm 2018, cả nước ghi nhận 7.585 trường hợp nghi sởi/rubella, trong đó có 3.529 ca được lấy mẫu bệnh phẩm và 1.794 ca dương tính với sởi, tăng gấp 8,4 lần so với số mắc sởi của cả năm 2017 (214 trường hợp).

Ho gà cũng là một trong 10 nguyên nhân hàng đầu gây tử vong ở trẻ sơ sinh trên toàn thế giới với ước tính khoảng 24 triệu trường hợp mắc và 160.000 trường hợp tử vong hàng năm ở trẻ em dưới 5 tuổi.

So với COVID-19 với tỷ lệ tử vong là khoảng 0,001% (1/10.000 trường hợp) ở trẻ em thì tỷ lệ tử vong ở trẻ em chưa được tiêm chủng mắc bệnh ho gà có thể lên tới 5%. Đối tượng mắc bệnh trong các vụ dịch này chủ yếu chưa được tiêm vaccine hoặc tiêm chưa đủ mũi.

Tỷ lệ tiêm chủng các vaccine trong TCMR ở trẻ em và các loại vaccine dự phòng khác đạt thấp liên quan đến COVID-19 có thể mất thêm nhiều thời gian nữa để nâng cao, đạt mức an toàn đảm bảo nền miễn dịch cộng đồng.

Điều đáng quan tâm là tình huống dịch sởi, ho gà…có thể lại bùng phát trên phạm vi toàn quốc sau đợt nới lỏng kiểm soát dịch COVID-19, khi các trẻ em cùng gia đình chưa có miễn dịch phòng bệnh có nguy cơ phơi nhiễm bệnh đâu đó quay trở lại trường học và tham gia sinh hoạt trong khối cộng đồng nguy cơ cao sau kỳ du lịch nghỉ mát mùa hè.

Do đó, yêu cầu cấp thiết của hệ thống y tế và chăm sóc sức khỏe là quyết liệt triển khai các biện pháp can thiệp kịp thời; cần thiết có sự vào cuộc của chính quyền địa phương, các ban ngành đoàn thể trong việc triển khai đồng bộ các giải pháp truyền thông, vận động đối tượng tiêm chủng, cung cấp đầy đủ dịch vụ tiêm chủng và có cơ chế mở rộng khả năng tiếp cận tiêm chủng toàn diện, đặc biệt chú trọng ở nhóm đối tượng nguy cơ cao để từng bước phục hồi công tác TCMR, không để xảy ra tình trạng "vùng lõm tiêm chủng".

Người dân cũng cần nâng cao nhận thức và chủ động tìm kiếm các dịch vụ tiêm chủng phù hợp hoàn cảnh, cùng nhau chúng ta góp phần hạn chế gánh nặng bệnh tật cho các mầm non tương lai.

Sáng 28/6: Biến thể phụ BA.5 lây lan nhanh thế nào? Hiệu quả bảo vệ sau tiêm vaccine COVID-19 mũi 4 ở cả 5 cấp độ

SKĐS - Biến thể phụ BA.5 của Omicron được cho là có khả năng lây lan nhanh đã xâm nhập vào Việt Nam. Tổ chức Y tế thế giới cảnh báo biến chủng mới có thể làm dịch bệnh phức tạp và gia tăng trở lại... Bộ Y tế khuyến cáo người dân, đặc biệt là những nhóm có nguy cơ cần tiêm đúng lịch, đủ liều.

Huyền Nguyễn (Viện Vệ sinh Dịch tễ Trung ương)

Tags: Covid-19 / tiêm vaccine / ho gà / sởi / viêm não / tiêm chủng mở rộng

Bình luận

Ý kiến của bạn

Xin vui lòng viết bằng tiếng việt CÓ DẤU

Tin Liên Quan

6.1.2 Translated version (English)

The Risk of Resurgence in Vaccine Preventable Infections after the easing of COVID-19 control

SKĐS - *The majority of cases of infectious diseases or diseases related to infections can be prevented by vaccines. There has been a clear sign of increased disease risk after the relaxation of restrictions in the fight against COVID-19.*

Summer is a time of increased travel and vacation activities, especially for families with students on summer break.

Gathering large numbers of people and exchanging between different regions at tourist destinations, airports, bus stations, train stations, etc., carries the potential for the spread of diseases such as COVID-19 and especially vaccine-preventable diseases like measles, pertussis, diphtheria, Japanese encephalitis, due to the disruption or delay of vaccination programs during the recent pandemic.

COVID-19 and its impact on immunization programs.

COVID-19 has caused significant impacts on all aspects of life, from health to the economy and politics of society as a whole. Despite the current containment of the pandemic and the gradual return to normalcy, COVID-19 remains an unpredictable threat due to its direct and indirect impacts.

After efforts to control the COVID-19 pandemic, the EPI has promoted vaccination and urgently provided catch-up immunization for individuals who have missed their scheduled vaccinations. Illustration image.

Vietnam has experienced four major waves of the COVID-19 pandemic and implemented social distancing measures or local lockdowns multiple times to prevent the spread of the virus. The Expanded Programme on Immunization (EPI) and private vaccination services have been temporarily suspended to enforce strategies in response to the pandemic, leading to many children missing their scheduled vaccinations.

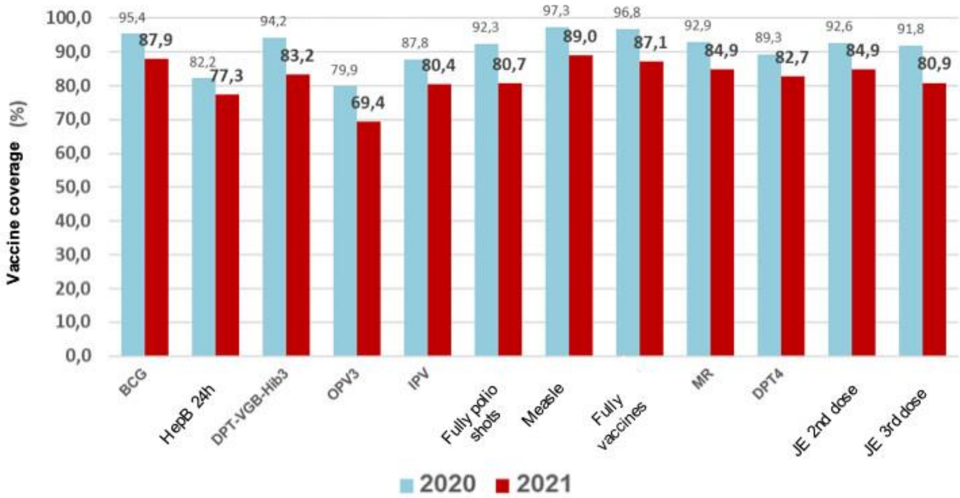
After the efforts to control the COVID-19 pandemic, the EPI has promoted vaccination and urgently caught up on missed vaccinations for individuals. However, there are still many parents who are hesitant to bring their children back for vaccination due to concerns about the risk of COVID-19 infection.

In addition, accessing vaccines after the pandemic has become even more challenging for vulnerable groups of children, including children from minority communities, children in difficult circumstances, those living in remote or rural areas, children whose parents work far away, and children in high-risk COVID-19 infection groups.

This has led to an increasing number of children not receiving timely vaccinations, resulting in gaps in immunity in some certain areas. This poses a potential risk for future disease outbreaks.

According to the interim report on the EPI in 2021 by the National EPI office, the vaccination coverage rates for most vaccines, except for DPT4, did not meet the annual targets in the EPI and were lower than in 2020. This indicates the unprecedented impact of the COVID-19 pandemic on the implementation of the EPI.

In terms of district-level scale, the number of districts with vaccination coverage rates ≥90% has decreased to the lowest level in the past 6 years, while the number of districts with vaccination coverage rates <80% has increased to the highest level in the past 6 years. This reflects the wide-ranging impact of the pandemic on the EPI.



The national-scale vaccination coverage rates in the EPI in 2020-2021

(Source: 2021 summary report – the National EPI)

The risk of increasing vaccine-preventable diseases in the near future

In recent weeks, according to statistical reports from the National Children's Hospital, the number of outpatient visits to the hospital has reached approximately 6,000 cases per day, which is 1.5 times higher than the peak period before COVID-19 appeared in Vietnam.

The majority of cases of infectious diseases or diseases related to infections can be prevented by vaccines. There has been a clear sign of increased disease risk after the relaxation of restrictions in the fight against COVID-19.

The decline in vaccination rates or delayed vaccination schedules, not only in Vietnam but also on an international level, poses a risk of outbreaks of dangerous diseases such as measles and pertussis. These diseases are highly contagious and have a higher basic reproduction number (R0) compared to COVID-19.

Measles virus is transmitted more easily in the air than COVID-19 and can also persist and spread from contaminated surfaces. The disease can even be transmitted 4 days before the onset of symptoms. A child with measles can infect around 90% of susceptible individuals who are not naturally immune or vaccinated.

In Vietnam, despite more than 30 years of successful vaccination programs, there have been some major measles outbreaks in recent years. A notable example is the outbreak in 2014, where over 30,000 suspected cases of fever and rash resembling measles were reported nationwide. Among them, more than 5,800 cases were confirmed through laboratory testing, and there were 147 measles-related deaths.

In 2018, Vietnam recorded 7,585 suspected cases of measles/rubella, with 3,529 cases tested and 1,794 cases confirmed as measles. This marked an 8.4-fold increase in measles cases compared to the entire year of 2017 (214 cases).

Pertussis is also one of the top 10 causes of infant mortality worldwide, with an estimated 24 million cases and 160,000 deaths annually in children under 5 years old.

Compared to COVID-19, which has a mortality rate of about 0.001% (1/10,000 cases) in children, the mortality rate in unvaccinated children with pertussis can be as high as 5%. The majority of cases in these outbreaks involve individuals who have not been vaccinated or have not received the complete vaccine dosage.

The vaccination coverage rates in children in the EPI and other vaccines remain low due to COVID-19 pandemic may take additional time to improve and reach a level that ensures the herd immunity.

It is concerning that outbreaks of diseases such as measles and pertussis could potentially resurge nationwide following the relaxation of COVID-19 control measures, as children and their families who lack immunity to these diseases may be exposed in schools and community settings after the summer vacation period.

Therefore, it is crucial for the healthcare system to implement timely interventions and for the authorities and relevant organizations to be actively involved in coordinating comprehensive communication strategies, mobilizing the target population for vaccination, providing adequate vaccination services, and expanding the accessibility of vaccination. Special attention should be given to high-risk groups to gradually restore the EPI activities and prevent any vaccination gaps.

Citizens also need to enhance their awareness and actively seek appropriate vaccination services. Together, we can contribute to reducing the burden of diseases on the future generations.

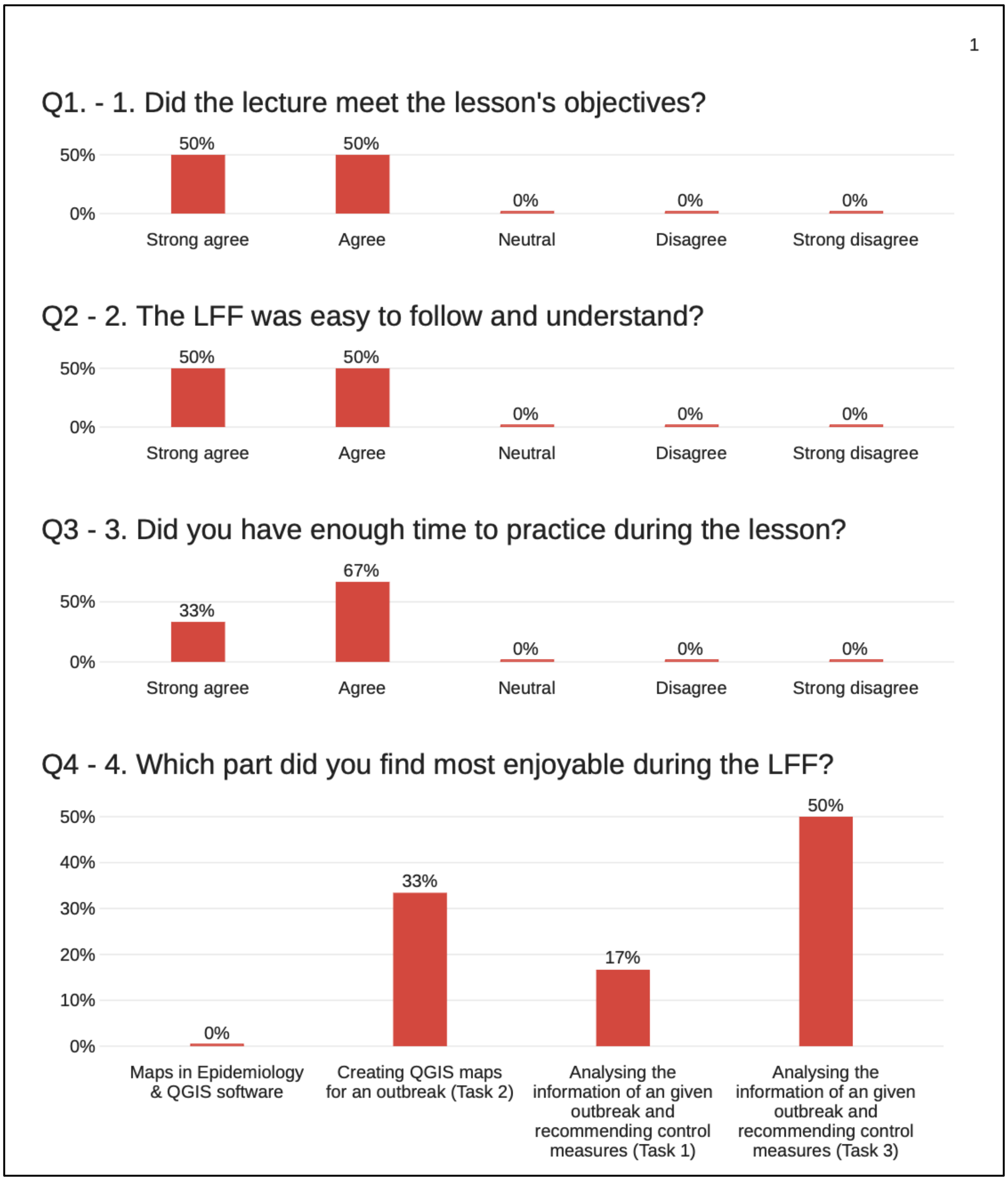
Huyen Nguyen, Pham Quang Thai
Vietnam National Institute of Hygiene and Epidemiology

6.2 Lesson from the field (LFF)

Topic: ***Mapping an outbreak: Plotting cases with specified spatial coordinates to QGIS***

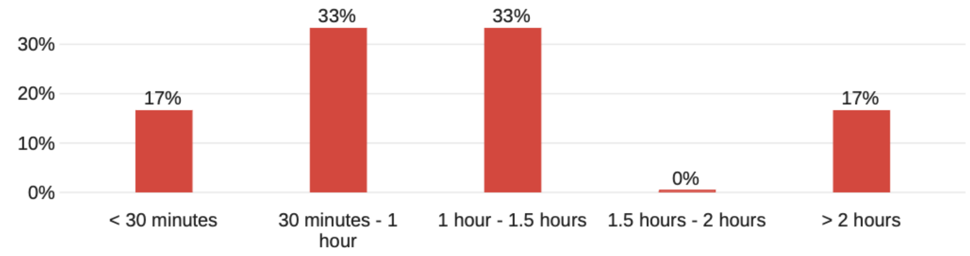
I conducted the LFF in 20 March 2022 with six scholars in my cohort. The LFF was divided to five sessions: (i) Maps in Epidemiology and QGIS software; (ii) Creating QGIS maps for an outbreak and did some exercises; (iii) Analysing the information of an given outbreak and recommending control measures and did some exercises; (iv) Quesstions and discussion; and (v) Evaluation.

The evaluation polling is depicted below (n=6):



2

Q5 - 5. How long did the LFF's exercises take you to complete?



Q6 - 6. What do you think any components that could be improved?

Being clear to inform people to load up the project for the work during the session.

Excellent and informative session and very well presented :)

Maybe put more exercise

It was really good and thorough. Huyen put a lot of thought into the LFF and made it very easy to understand.

Very clear instructions, no suggestions!

Great work Huyen!

This session included two sections: 1) Pre-reading materials for the LFF and 2) PowerPoint introduction including some practice exercises.

6.2.1 Pre-reading materials

This lesson from the field (LFF) is a self-directed learning exercise and will be emailed to participants:

- Topic: MAE LFF – Huyen Thi Nguyen
- Time: March 20, 2022 10:00AM Vietnam time
- LFF folder: LFF Group 1 / LFF 6 (Huyen)

  https://anu365-my.sharepoint.com/personal/u7402682_anu_edu_au/_layouts/15/onedrive.aspx?id=%2Fpersonal%2Fu7402682%5Fanu%5Fedu%5Fau%2FDocuments%2FLFF%20Group%201&ct=1688975390184&or=OWA%2DNT&cid=866d48b7%2De99f%2Dd3f7%2D1902%2Da0d08fb76b00&ga=1&WSL=1

- Join Zoom Meeting: https://anu.zoom.us/j/84155020378?pwd=ZXYzUDV1T0NuaCtxRXpTeXdaSTk3UT09

Mapping an outbreak:
Plotting cases with specified spatial coordinates to QGIS

Learning objectives

Students will be able to:

1. Create an outbreak map using QGIS software
2. Analyse the information of an outbreak together with maps

Background and rationale

Maps are used in public health to represent geographic location of events or attributes, it is a great visual communication tool. Maps commonly used in field epidemiology are of 2 types: area maps and spot maps.

Area maps can be used to show rates of disease or other health conditions in various locations by using varied shades or colors. Area maps are very useful for communicating trends or averages in an area and can be used to analyse outbreaks.

Spot maps use dots or other symbols to show where each case lived or was exposed. Spot maps are very useful to demonstrate geographic distribution of cases to trace causes of infection or exposure. However, spot maps do not show risk because they do not take into account population size. Even if a spot map shows many dots in the same area, the risk of disease may not be high if that area is densely populated.

Analysing and communicating epidemiology data by presenting it on a map are essential skills for a field epidemiologist. There are many different map applications that can be used, in this lesson, some functions of QGIS will be introduced and practiced. QGIS (formerly Quantum GIS) is an open source geographic information system (GIS). This software is a free alternative to proprietary GIS software such as ESRI's ArcGIS products which can be very expensive. QGIS incorporates similar functions and features as its proprietary counterparts and allows users to display, manipulate and create spatial data. It supports a variety of spatial data file extensions (.shp, .tif, .csv, .img, etc.) and is compatible on Linux, Unix, Mac, and Windows operating systems.

Scenario

Set in 2019:

You are the WHO's field epidemiologist sent to Queensland in October 26, 2019 deployed to help respond to a Measles outbreak. In October 25, 2019, Queensland Department of Health reported a measles cluster of 5 laboratory-confirmed cases in Southeast Brisbane (2 primary school students from a same school, 2 adults 30 and 38 years old have no epidemiological link, 1 adult 28 years old had 2-week travel to Philippines and just returned home 3 days ago). All cases are now being treated in isolation wards in local hospitals.

With current case investigation data, you have created a spot map of this outbreak as follows.

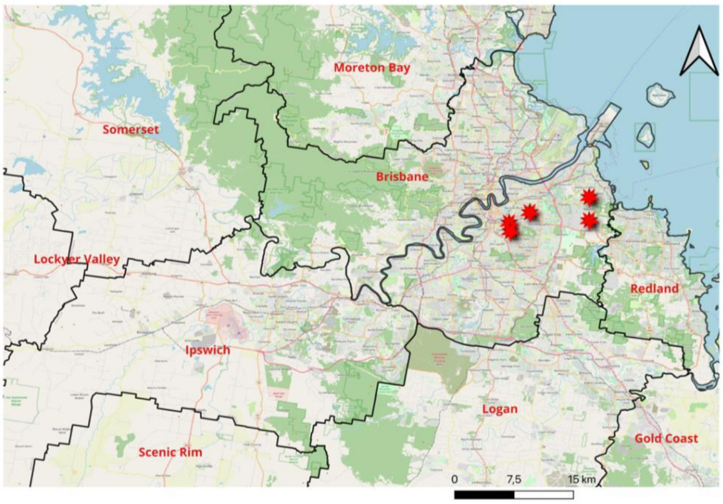


Fig 1: Spatial distribution of reported cases of measles in Brisbane, Queensland, 25 October 2019

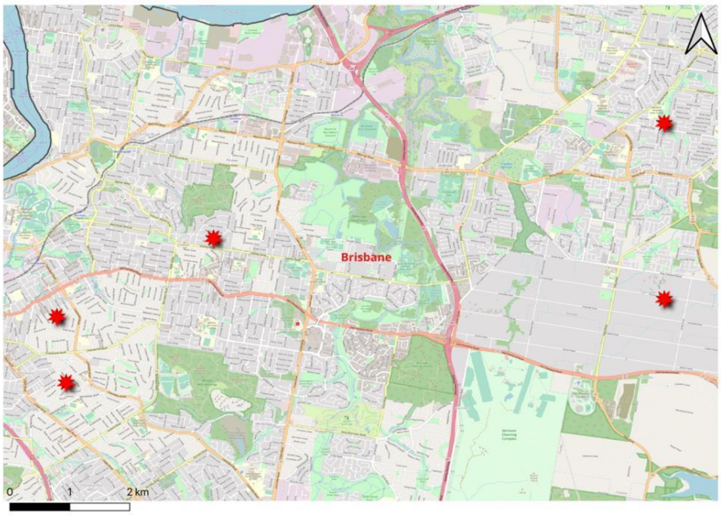


Fig 2: Zoom in on the affected area: Spatial distribution of reported cases of measles in Brisbane, Queensland, 25 October 2019

Question 1: Based on the information provided by local health departments and the initial map you drew, please give your comments on the current outbreak situation; additional information to be collected; and what recommendations should be made in this stage?

The day after (27 Oct 2019), you and local staffs do a field investigation and record additional information as showed in the table below. You need to show the change of case distribution on map to report in a meeting with local leaders.

City	25 Oct (cases)	27 Oct (cases)	Total	Epid link (new cases)
Brisbane	5	6	11	1 adult case: Travel (philippines) 2 pupils in the same school with 2 previous cases 3 adults
Redland	0	1	1	1 adult
Logan	0	7	7	1 couple; 4 adults, 1 pupil
Ipswich	0	1	1	1 adult
Somerset	0	1	1	1 old man with underlying health conditions
Moreton Bay	0	2	2	2 adults
Total	**5**	**18**	**23**	

Question 2: Practice creating an up-to-date map of newly investigated cases

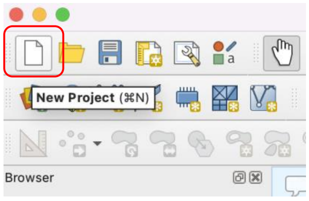
Instruction
You will create a map to update outbreak situation by geographical location
To do this, follow these steps:
1. *Make sure you have downloaded and installed approriate QGIS software (See **appendix 1**)*
2. *Download the map documents in the attached folder*
   a. *Queensland_city.cpg*
   b. *Queensland_city.dbf*

c. *Queensland_city.prj*
d. *Queensland_city.qmd*
e. ***Queensland_city.sph***
f. *Queensland_city.shx*
g. ***lat long cases in Queenland_1.csv***
h. ***lat long cases in Queenland_2.csv***

3. *Create a new project*

   Option 1: Keyboard shortcut: Ctrl + N

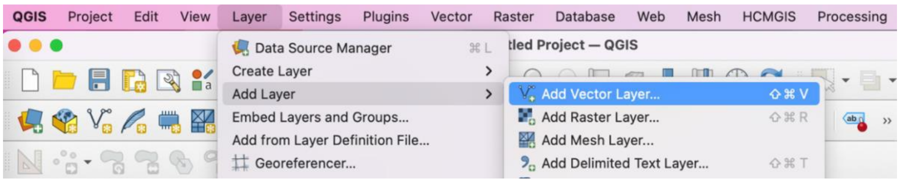
   Option 2: Click this symbol on the menu



   Name the project and save the file to your computer.

4. *Create layers*

   Layer > Add Layer > Add Vector Layer



   Then, the window "Data Source Manager" appears, in the "Source" box, click on the button "..." to find the folder containing vector data files to open.

   + To open a map, select the .shp files.

   + Click on button "Open" to open spatial file, click on button "Add" to add a new vector layer

   + Do the same steps with other files

   Notice: The layers Panel lists all the layers in the project and helps you manage their visibility. A layer can be selected and dragged up or down in the legend to change the Z-ordering. Z-ordering means that layers listed nearer the top of the legend are drawn over layers listed lower down in the legend.

5. *Insert satellite map into the layers panel*
   - *Browser > XYZ Tiles > OpenStreetMap: Select and drag into Layers*

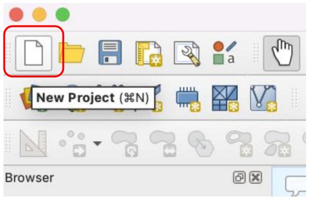
     Notice: When dragging and dropping, the OpenStreetMap item must be below the case spot coordinate.

c. Queensland_city.prj
d. Queensland_city.qmd
e. Queensland_city.sph
f. Queensland_city.shx
g. lat long cases in Queenland_1.csv
h. lat long cases in Queenland_2.csv

3. *Create a new project*

   Option 1: Keyboard shortcut: Ctrl + N

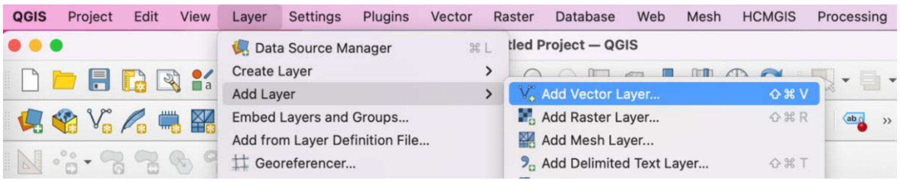
   Option 2: Click this symbol on the menu



   Name the project and save the file to your computer.

4. *Create layers*

   Layer > Add Layer > Add Vector Layer



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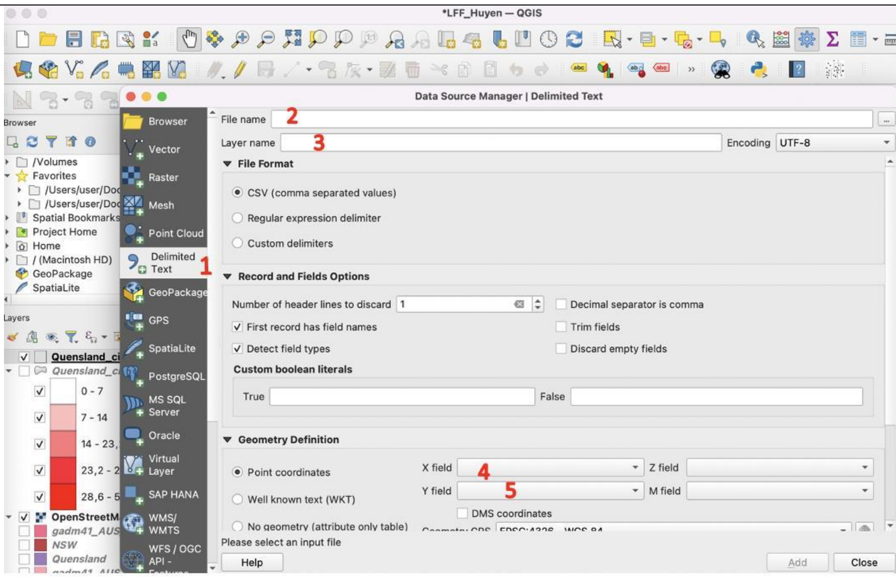
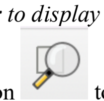
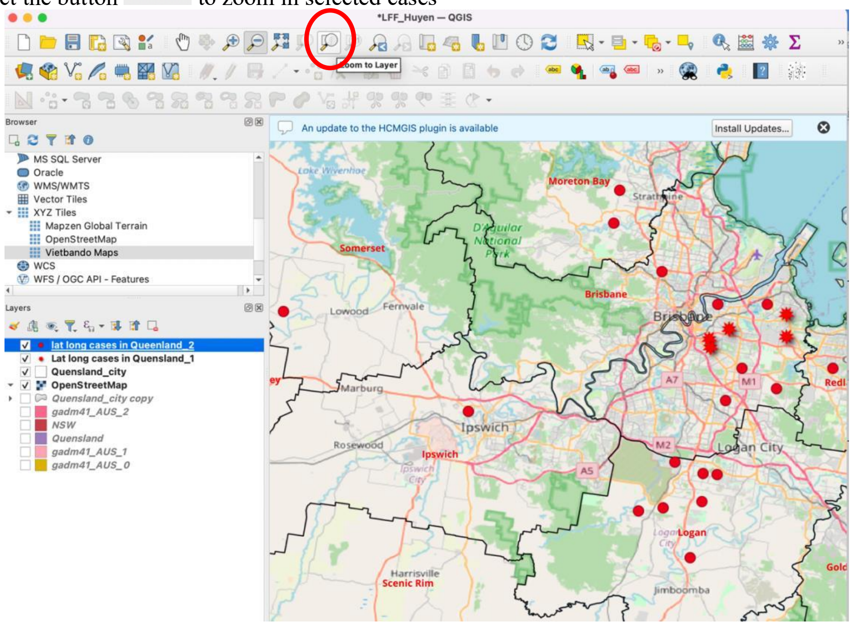
5. *Insert satellite map into the layers panel*
   - *Browser > XYZ Tiles > OpenStreetMap: Select and drag into Layers*

     Notice: When dragging and dropping, the OpenStreetMap item must be below the case spot coordinate.



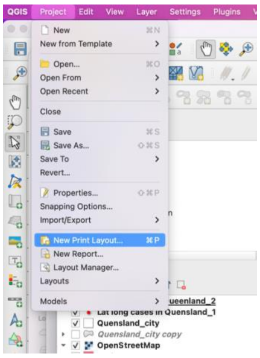
7. *Zoom in the map at the case location*
- *Select the layer to display*
- Select the button  to zoom in selected cases



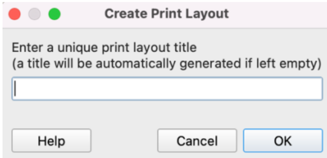
LFF (Pre-Reading) 6 of 12

8. *Export the map*

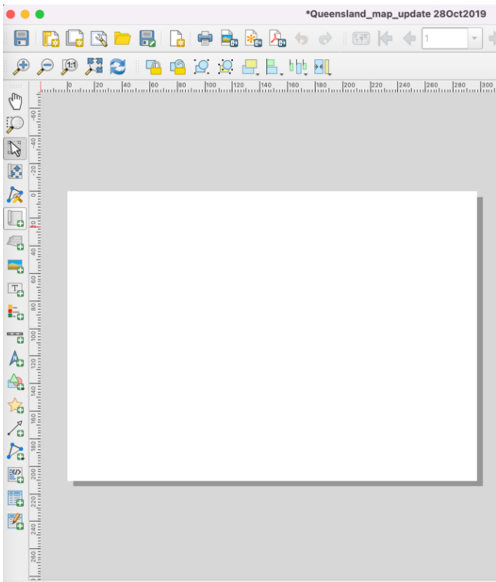
- *Project > New Print Layout (Ctrl + P)*



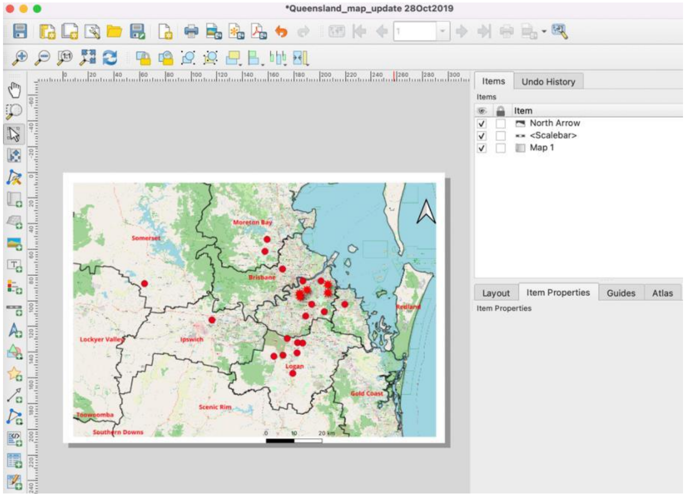
- *Named & saved it*



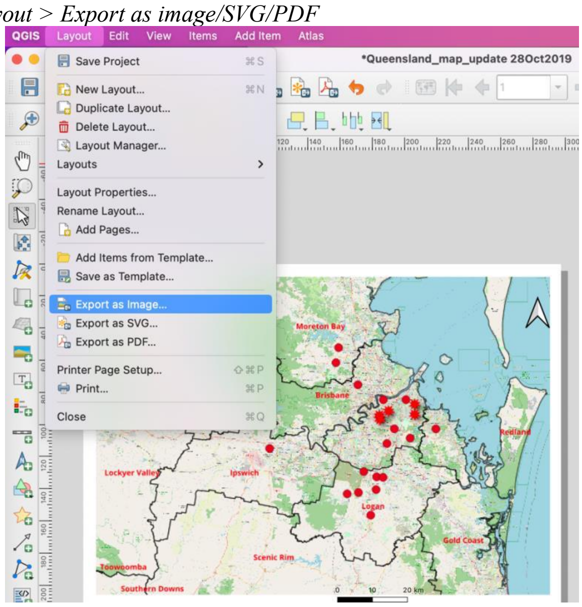
- Click on icon (add new map) on the vertical menu, or click on "Show" on menu function, then select "Add" new map.
- Draw the map to the paper by holding the left mouse button on the printed paper and dragging to the desired extent.



- *Edit layout, add more functions from the toolbar (compass, scale, legend, …)*



- *Export a map: Layout > Export as image/SVG/PDF*



- *Save the map to your folder*

LFF (Pre-Reading) 8 of 12

Insert picture of map that you have created here

Question 3: Based on the updated map you just drew, what are your comments and recommendations or solutions to control the outbreak?

Please contact me on Huyen.Nguyen@anu.edu.com or on Whatsapp so that we can sort any issues with QGIS or any files.

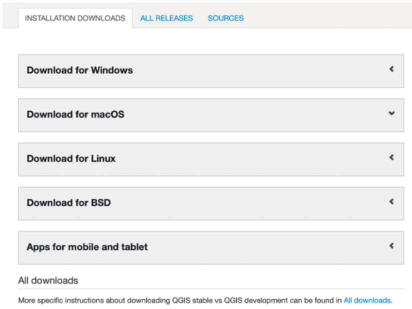
Appendix 1: Instructions for downloading and installing QGIS

1. Download QGIS software & Install

- Free download at the homepage of QGIS

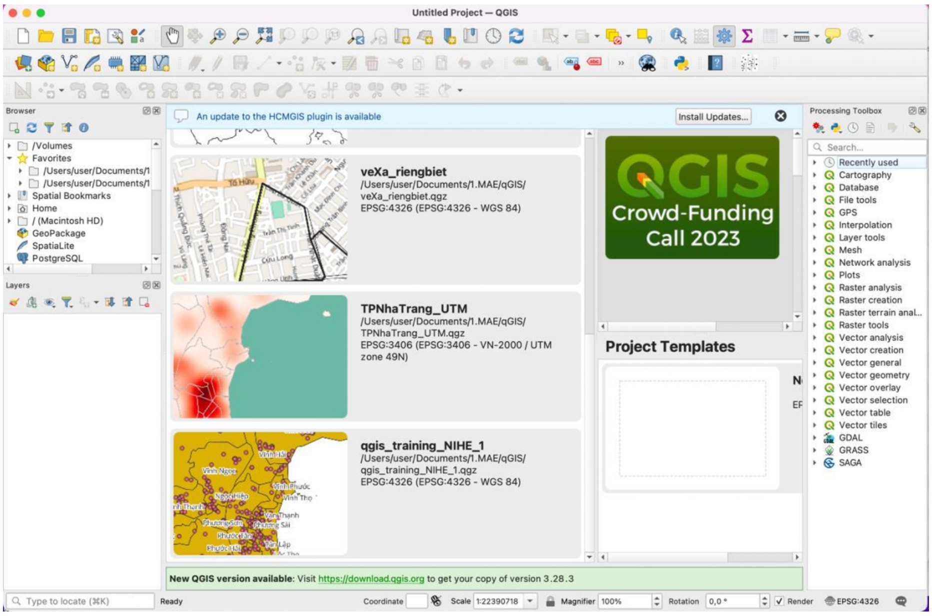
  Link to download: https://qgis.org/en/site/forusers/download.html

- Select compatible software to your operating system:



- Interface after installation:

- Double click on the symbol on Desktop to run the software
- Main interface of the QGIS software

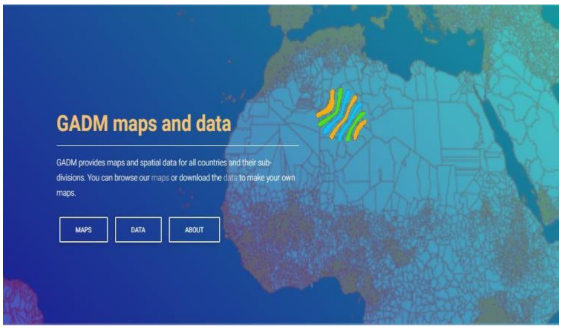


2. **Download maps and spatial data (Self-practice)**

Purpose: Select maps by country, province, district and commune

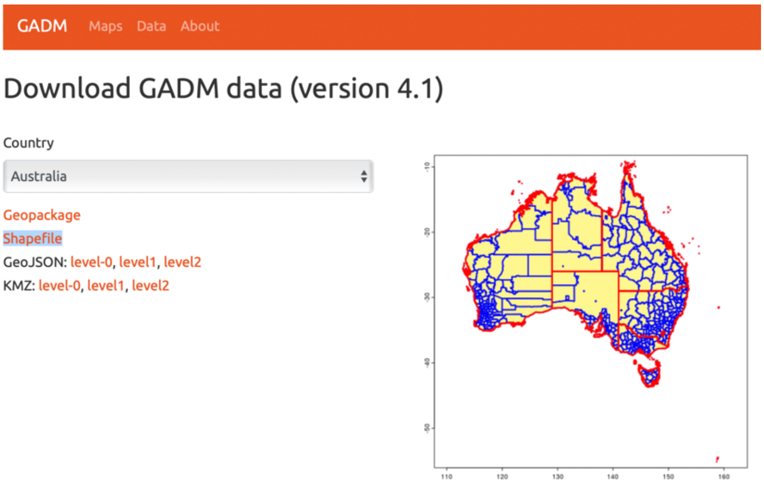
Source: GADM provides maps and spatial data for all countries and their sub-divisions.
https://gadm.org

In the home page GADM, select “Data”



- In the new windows, click on “country”

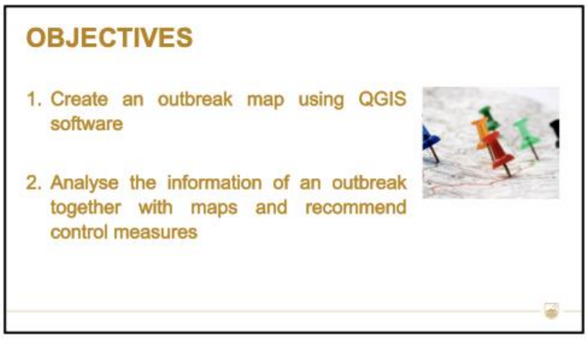
Select data by country: https://gadm.org/download_country.html
 Click “shapefile” and save it.

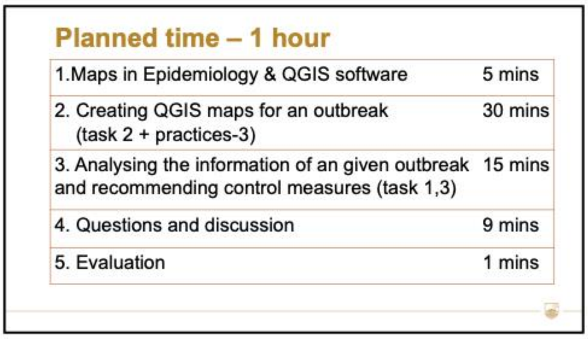


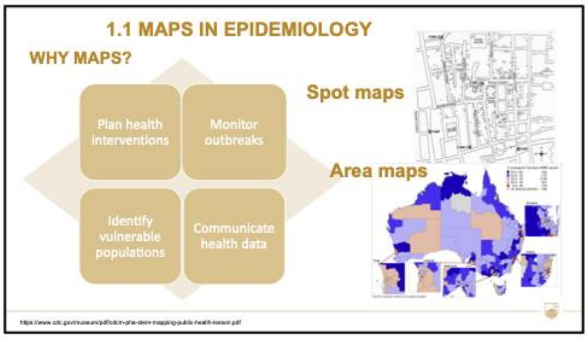
Reference

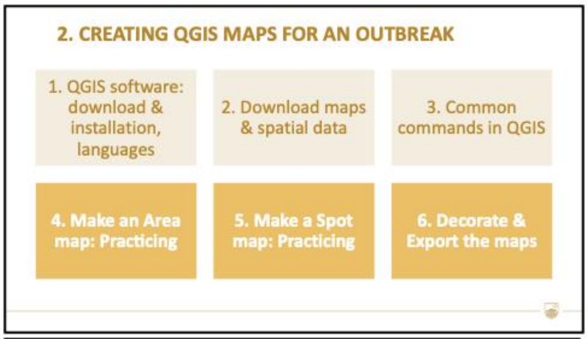
1. **QGIS Documentation** https://www.qgis.org/en/docs/index.html
2. **QGIS Training Manual** – QGIS Documentation : http://doc.qgis.org/2.14/en/docs/training_manual/

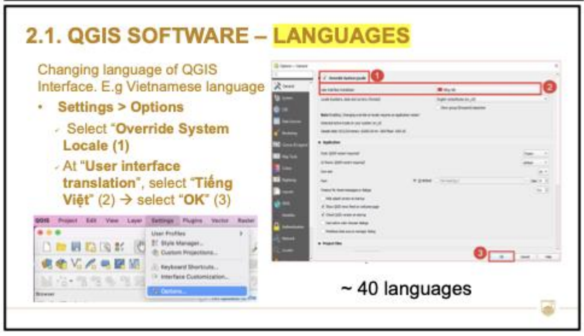
6.2.2 Lesson presentation

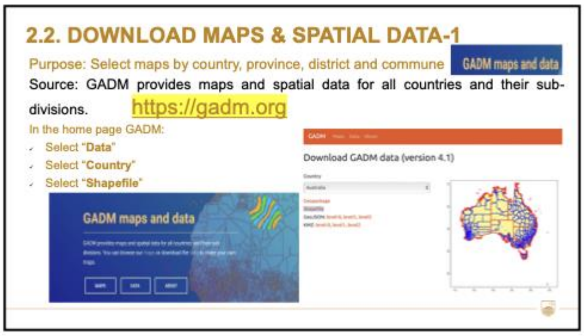




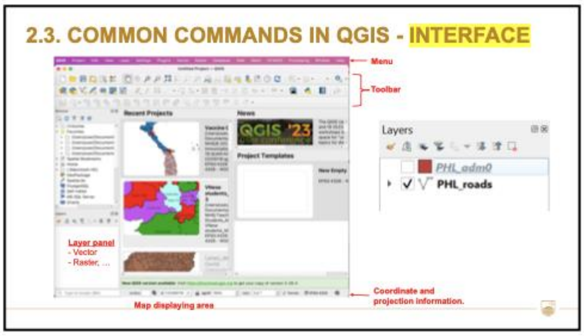


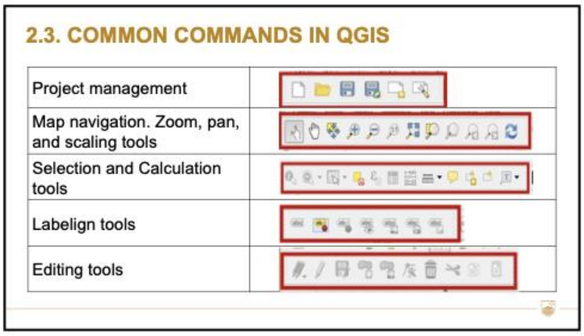




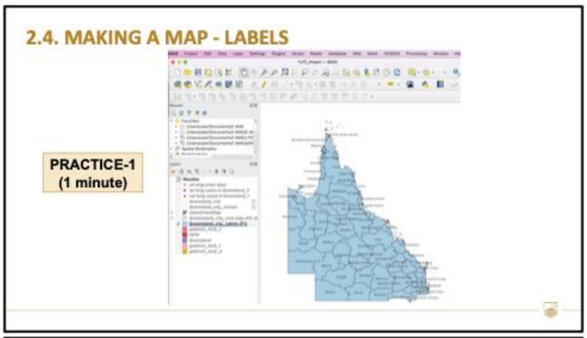

2.2. DOWNLOAD MAPS & SPATIAL DATA-1
GADM maps and data
Purpose: Select maps by country, province, district and commune
Source: GADM provides maps and spatial data for all countries and their sub-divisions.
https://gadm.org
In the home page GADM:
Select "Data"
Select "Country"
Select "Shapefile"
GADM maps and data
Download GADM data (version 4.1)

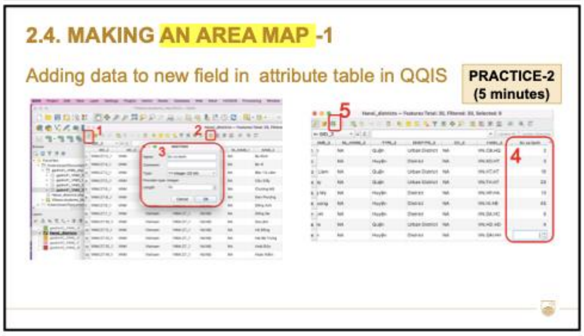

2.2. DOWNLOAD MAPS & SPATIAL DATA-2
Free GIS Data
Source:
http://freegisdata.rtwilson.com
In the home page, select "DIVA-GIS Country Data"
DIVA-GIS
Download data by country

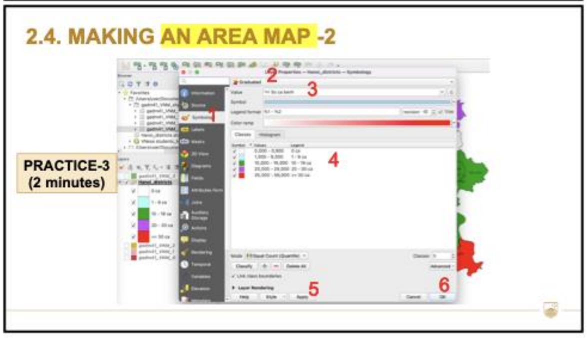

2.3. COMMON COMMANDS IN QGIS - INTERFACE
Menu
Toolbar
Layers
PHL_adm0
PHL_roads
Layer panel
- Vector
- Raster, ...
Map displaying area
Coordinate and projection information.

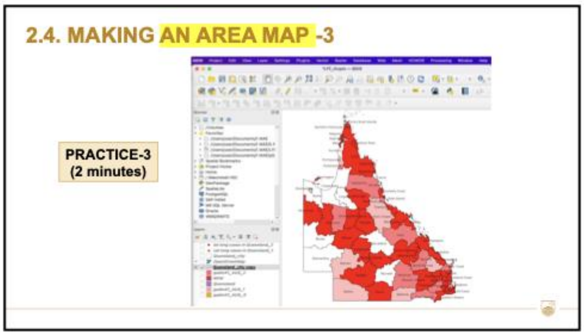

2.3. COMMON COMMANDS IN QGIS
Project management
Map navigation. Zoom, pan, and scaling tools
Selection and Calculation tools
Labelign tools
Editing tools

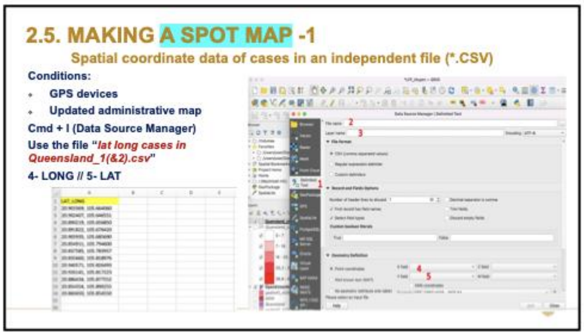

2.4. MAKING A MAP - LABELS
PRACTICE-1
(1 minute)
1
2
3
4
5


2.4. MAKING A MAP - LABELS
PRACTICE-1
(1 minute)


2.4. MAKING AN AREA MAP -1
Adding data to new field in attribute table in QQIS
PRACTICE-2
(5 minutes)
1
2
3
4
5


2.4. MAKING AN AREA MAP -2
PRACTICE-3
(2 minutes)
1
2
3
4
5
6


2.4. MAKING AN AREA MAP -3
PRACTICE-3
(2 minutes)


2.5. MAKING A SPOT MAP -1
Spatial coordinate data of cases in an independent file (*.CSV)
Conditions:
GPS devices
Updated administrative map
Cmd + I (Data Source Manager)
Use the file "lat long cases in Queensland_1(&2).csv"
4- LONG // 5- LAT

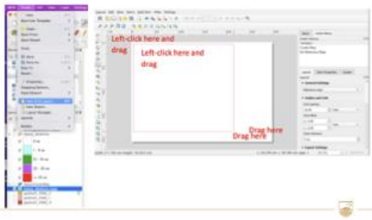
2.5. MAKING A SPOT MAP -2

Q2: Creating an up-to-date map of newly investigated cases ✓

2.6. DECORATE & EXPORT THE MAPS -1

- Project > New Print Layout (Ctrl P)> Named
- Add map

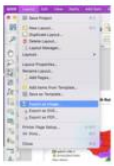
1. Add North Arrow
2. Add scale bar
3. Add Legend
4. Add Label

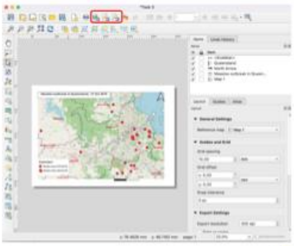


2.6. DECORATE & EXPORT THE MAPS -2

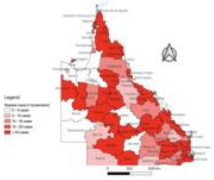
Layout

- Export as image (.png)
- Export as pdf





2.6. DECORATE & EXPORT THE MAPS -3



Q2: Creating an up-to-date map of newly investigated cases ✓

3. Analyzing the information of a given outbreak and recommending control measures (Q1&3)

Australian National University

Scenario

Distribution of measles cases in Brisbane, Oct 25, 2019

A Measles outbreak in Queensland

- **October 25, 2019:** 5 laboratory-confirmed cases in Brisbane
  - ✓ 2 primary school students from a same school,
  - ✓ 2 adults 30 and 38 years old had no epidemiological link,
  - ✓ 1 adult 28 years old had 2-week travel to Philippines and just returned home 3 days ago
- **October 26, 2019:** You were here to help respond to this outbreak

Q1: Based on the information provided by local health departments and the initial map you drew, please give your comments on the current outbreak situation; additional information to be collected; and what recommendations should be made in this stage?

- Comments:
  - ✓ Limited data (onset dates, contacts,…)
  - ✓ Other cases? Index case?
- Information need to be collected:
  - ✓ Outbreak? Case definitions?
  - ✓ **Current cases:** Clinical history, onset dates, vaccination status, epi link → Index case?
  - ✓ **Contacts**: travel history, vaccination status, symptom,
  - ✓ **Community**: MCV coverage?
- Recommendations:
  - ✓ **Public health intervention**:
    - ➢ Public health alert, case finding & contact tracing
    - ➢ Vaccination - MCV?
  - ✓ **Patients & hospital**: isolate, treat well

Distribution of measles cases in Brisbane, Oct 25, 2019

Q1: Based on the information provided by local health departments and the initial map you drew, please give your comments on the current outbreak situation; additional information to be collected; and what recommendations should be made in this stage?

- Discussion:

Should we need to implement **a vaccination campaign** in the context of an outbreak?

- ✓ When?
- ✓ Where?
- ✓ How?

Distribution of measles cases in Brisbane, Oct 25, 2019

Q1: Based on the information provided by local health departments and the initial map you drew, please give your comments on the current outbreak situation; additional information to be collected; and what recommendations should be made in this stage?

- Discussion:

Should we need to implement a vaccination campaign in the context of an outbreak?

- ✓ When?
  - Community transmission
  - Low MCV coverage
- ✓ Where?
  - Affected areas?
  - **Encirclement injection** should be given around **case-free areas** to create a **buffer** to prevent further spread.
- ✓ How?
  - Pay attention when vaccinating in affected areas because maybe vaccination sessions are an opportunity for cases to meet and increase the chance of spreading?

Distribution of measles cases in Brisbane, Oct 25, 2019

Q3: Based on the updated map you just drew, what are your comments and recommendations or solutions to control the outbreak?

City	25 Oct (cases)	27 Oct (cases)	Total	Epid link (new cases)
Brisbane	5	6	11	1 adult case: Travel (philippines) 2 pupils in the same school with 2 previous cases 3 adults
Redland	0	1	1	1 adult
Logan	0	7	7	1 couple; 4 adults, 1 pupil
Ipswich	0	1	1	1 adult
Somerset	0	1	1	1 old man with underlying health conditions
Moreton Bay	0	2	2	2 adults
Total	5	18	23	

Q3: Based on the updated map you just drew, what are your comments and recommendations or solutions to control the outbreak?

- Comments:

✓ Many more cases (5→23 cases)/2 days– # Brisbane (1→ 6 areas): community transmission.

✓ Limited data (onset dates, index case): 1 or more infectious sources?

- Recommendations:

✓ Public health intervention:
  ➢ Public health alert-increased spread of measles,
  ➢ Case finding & contact tracing / testing
  ➢ Vaccination - MCV

✓ Patients & hospital: quarantine, treat well, the treatment and isolation area

✓ Authorities: shut down the schools?

Q3: Based on the updated map you just drew, what are your comments and recommendations or solutions to control the outbreak?

- Discussion:

✓ When should we shut down the schools?

Q3: Based on the updated map you just drew, what are your comments and recommendations or solutions to control the outbreak?

- Discussion:

✓ When should we shut down the schools?
  ✓ Consider closing the schools or others because this measure only slows the spread of the outbreak but does not stop transmission of the outbreak.
  ✓ For classes with confirmed cases, suspected cases or close contacts, these classes can be self-isolate at home.

REFERENCES

1. QGIS Documentation https://www.qgis.org/en/docs/index.html
2. QGIS Training Manual – QGIS Documentation : http://doc.qgis.org/2.14/en/docs/training_manual/
3. YouTube channel – (PGS.TS.Pham Quang Thai, 2023) https://www.youtube.com/watch?v=z7j3QVzbY_Q&list=PL4wcuB0inYYISx7CEwbSc0pSdxV_tJrFA
4. Hướng dẫn sử dụng phần mềm QGIS vẽ bản đồ dịch tễ bệnh truyền nhiễm, Viện Pasteur Nha Trang, 2022

4. Q & A

Australian National University

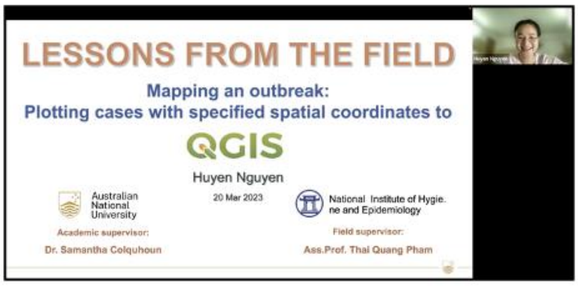
Huyen.Nguyen@anu.edu.au

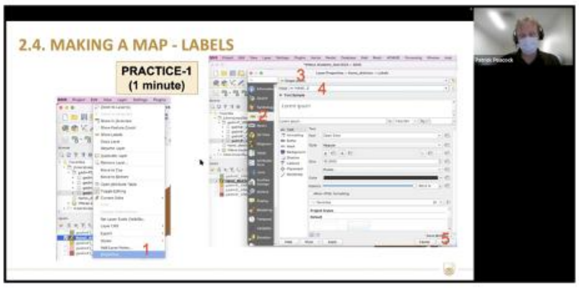
5. EVALUATION

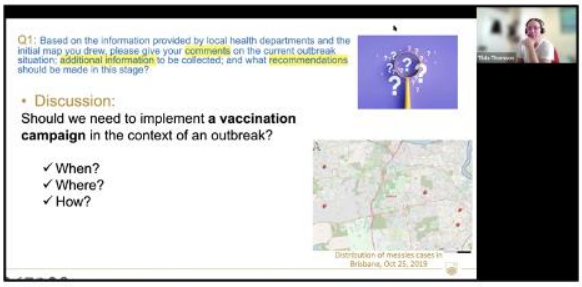
Australian National University

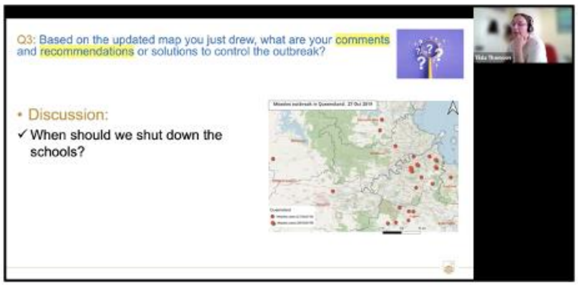
https://anu.au1.qualtrics.com/jfe/form/SV_6g3Pkx5b6rdoM3s

6.2.3 Lesson photos









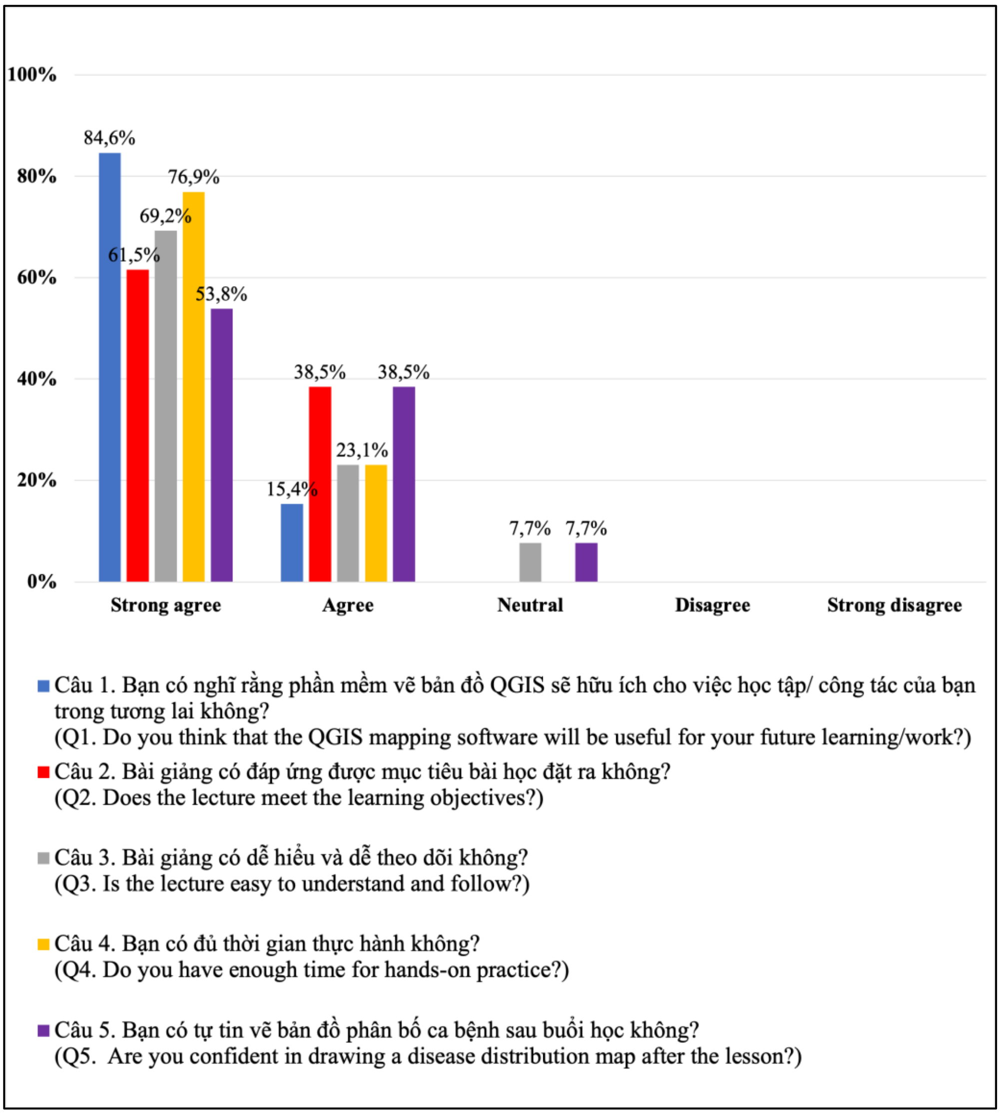
6.3 Teaching experience

Topic: **Guide to Using QGIS Software for Drawing Infectious Disease Epidemiology Maps.**

I conducted a teaching session of this topic on 13 March 2022 for 13 6-year students of Hanoi Medical University. The session was 2.5 hours long, conducted in person at NIHE.

I was able to work through the exercises and conducted a fruitful discussion with all attendees, with the assistance of my MAE colleague – Ms. Hien Nguyen. Materials for the teaching session included a pre-reading material, a PowerPoint presentation and other online resources.

Below is the evaluation of the session.



6.3.1 Pre-reading materials

HƯỚNG DẪN CÀI ĐẶT PHẦN MỀM QGIS

Huyen Nguyen

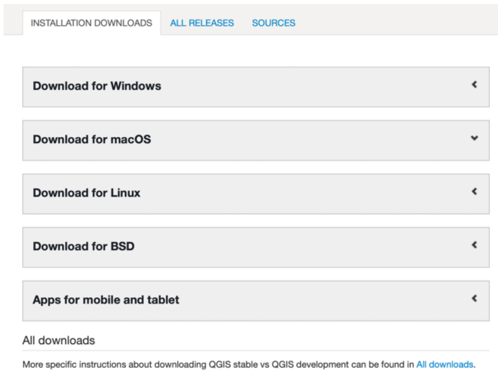
Lưu ý: Việc tải và cài đặt phần mềm thông thường mất khoảng 30 phút, tuy nhiên có thể kéo dài tới **vài tiếng đồng hồ** - tuỳ thuộc vào tốc độ Internet và máy tính của bạn. Vui lòng cân đối thời gian của bạn để hoàn tất việc cài đặt trước buổi học. Bài học gồm nhiều hoạt động thực hành vẽ bản đồ nên các bạn mang máy tính cá nhân theo để thao tác.

1. Tải phần mềm

- Truy cập trang chủ của phần mềm QGIS để tải miễn phí:

  https://qgis.org/en/site/forusers/download.html

- Chọn phần mềm tương thích với cấu hình máy tính của bạn để tải, lưu, và kích hoạt:



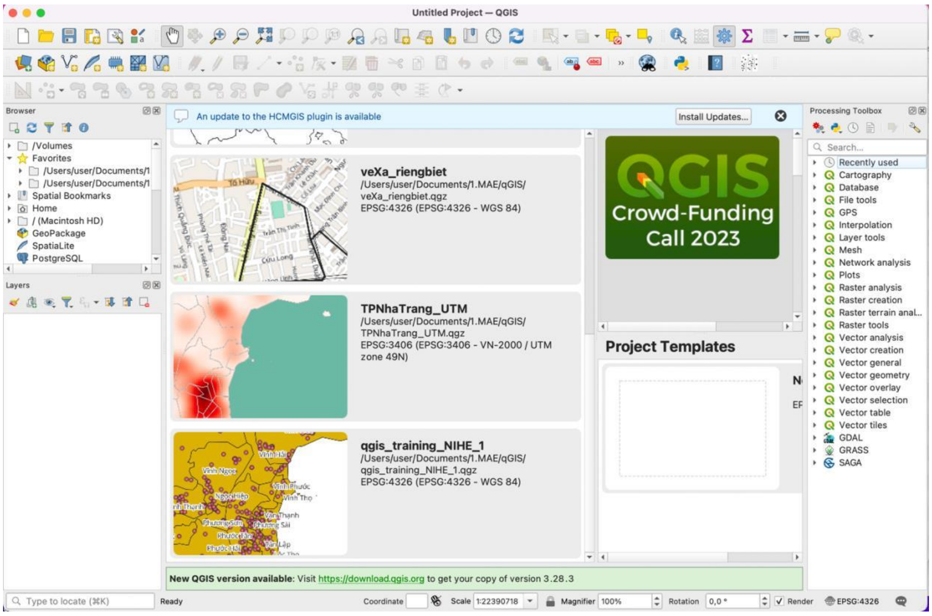
2. Giao diện sau khi cài đặt:

Nhấp kép chuột vào biểu tượng này trên màn hình máy tính để chạy phần mềm.

Giao diện khi bắt đầu chạy phần mềm:

(Pre-reading) 1 of 2

Giao diện khi cài đặt phần mềm thành công:

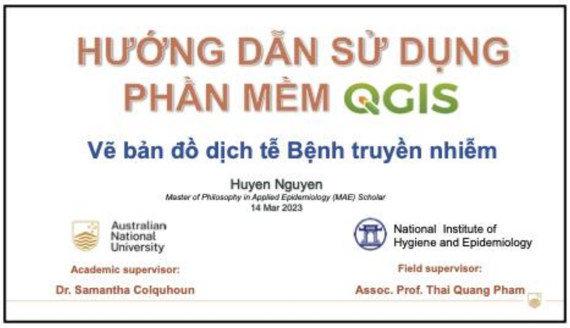


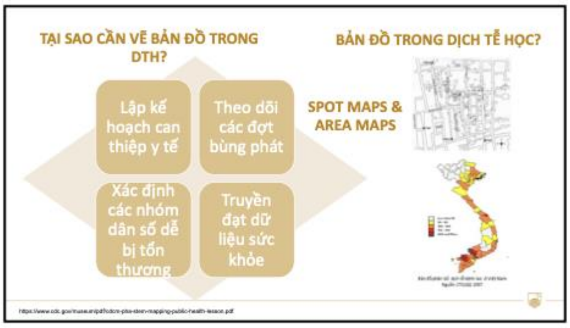
Tài liệu tham khảo:

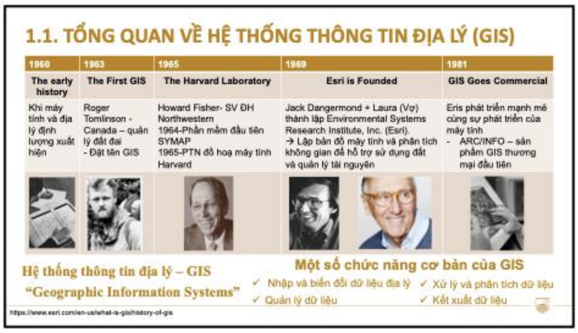
1. **QGIS Documentation** https://www.qgis.org/en/docs/index.html
2. **QGIS Training Manual** – QGIS Documentation : http://doc.qgis.org/2.14/en/docs/training_manual/
3. **YouTube channel – (PGS.TS.Pham Quang Thai, 2023)** https://www.youtube.com/watch?v=z7j3QVzbY_Q&list=PL4wcuB0inYYISx7CEwbSc0pSdxV_tJrFA

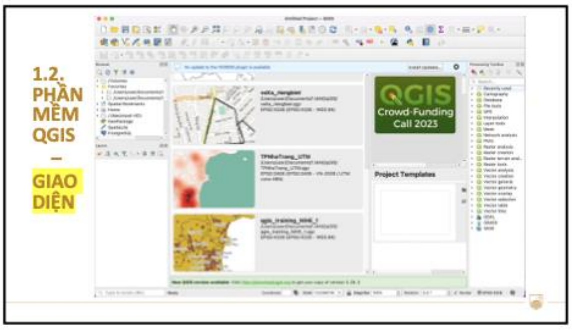
(Pre-reading) 2 of 2

6.3.2 Lesson presentation





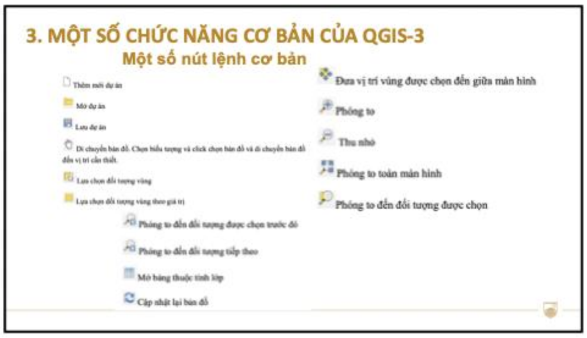





2. TẢI BẢN ĐỒ VÀ DỮ LIỆU KHÔNG GIAN
Mục đích: Tải bản đồ & dữ liệu không gian theo quốc gia, khu vực, tỉnh, huyện, xã…
Nguồn: GADM: https://gadm.org
Chọn "Data"
Chọn "Country"
Chọn "shapefile"
Download GADM data (version 4.1)


3. MỘT SỐ CHỨC NĂNG CƠ BẢN CỦA QGIS-1
1. Các nhóm chức năng (Menu)
2. Các thanh công cụ (Toolbar)
3. Các bảng điều khiển (Panel)
4. Vùng hiển thị bản đồ

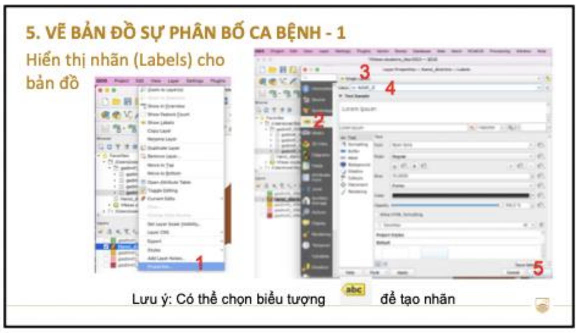

3. MỘT SỐ CHỨC NĂNG CƠ BẢN CỦA QGIS-2
Xem trên phần mềm
Thanh công cụ cơ bản
1. Dự án (Project)
2. Chỉnh sửa (Edit)
3. Xem (View)
4. Lớp (Layer)
5. Thiết lập (Settings)
6. Mở rộng (Plugins)
7. Database
8. GRASS
9. Vector
10. Raster


3. MỘT SỐ CHỨC NĂNG CƠ BẢN CỦA QGIS-3
Một số nút lệnh cơ bản
Thêm mới dự án
Mở dự án
Lưu dự án
Di chuyển bản đồ. Chọn biểu tượng và click chọn bản đồ và di chuyển bản đồ đến vị trí cần thiết.
Lựa chọn đối tượng vùng
Lựa chọn đối tượng vùng theo giá trị
Phóng to đến đối tượng được chọn trước đó
Phóng to đến đối tượng tiếp theo
Mở bảng thuộc tính lớp
Cập nhật lại bản đồ
Đưa vị trí vùng được chọn đến giữa màn hình
Phóng to
Thu nhỏ
Phóng to toàn màn hình
Phóng to đến đối tượng được chọn

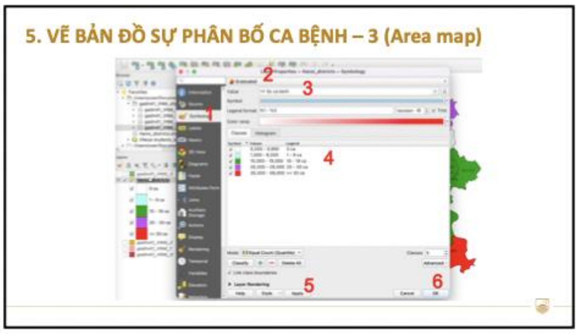

3. MỘT SỐ CHỨC NĂNG CƠ BẢN CỦA QGIS-4
- Thêm 1 lớp dữ liệu Vector
- Thao tác các lớp (Hiển thị, sắp xếp, gỡ bỏ, nhân bản)
- Lựa chọn khu vực địa lý
- Xoá các khu vực địa lý
- Trích xuất khu vực địa lý được chọn
Để chọn bản đồ hành chính Việt Nam, chọn file dữ liệu vector:
+ gadm41_VNM_0.shp: Hiện thị bản đồ đất nước Việt Nam.
+ gadm41_VNM_1.shp: Hiện thị chi tiết đến các Tỉnh/TP của Việt Nam.
+gadm401_VNM_2.shp: Hiện thị chi tiết đến các Quận/Huyện/Thị xã/Thành phố VN
+ gadm41_VNM_3.shp: Hiện thị chi tiết đến các bản đồ Xã/Phường/Thị trấn VN
Lưu ý: File dữ liệu vector trên cùng sẽ được ưu tiên hiển thị, để chọn hiện thị một lớp dữ liệu vector bất kỳ chọn ✓tại ô Checkbox bên cạnh.

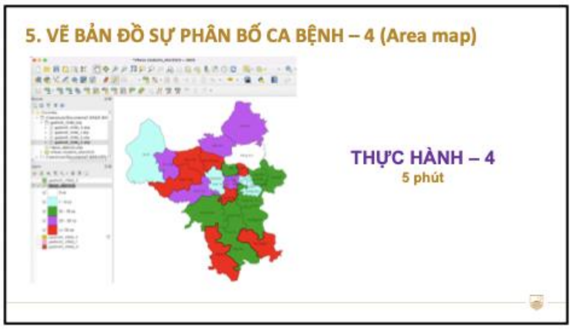

THỰC HÀNH – 1
Trích xuất Layer tuyến Quận/Huyện của TP. Hà Nội
(5 phút)
Ưu điểm:
Tạo trực tiếp 1 hoặc nhiều layer mới và không ảnh hưởng đến layer gốc.
Đảm bảo giá trị layer gốc không bị mất dữ liệu.

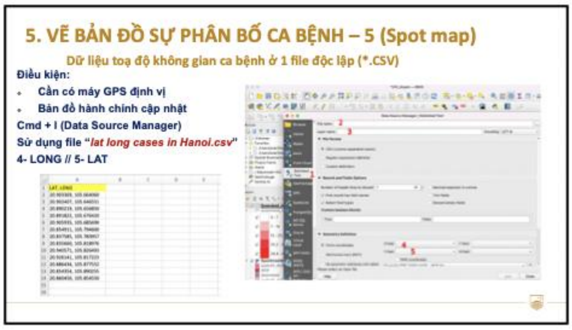

4. DỮ LIỆU THÔNG TIN CA BỆNH
TẠO TRƯỜNG MỚI – Thủ công
THỰC HÀNH – 2
5 phút
1
2
3
4
5

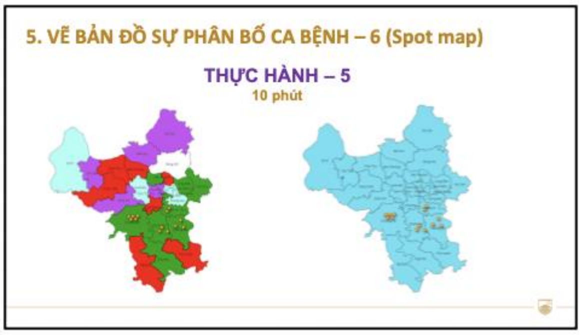

5. VẼ BẢN ĐỒ SỰ PHÂN BỐ CA BỆNH - 1
Hiển thị nhãn (Labels) cho bản đồ
1
2
3
4
5
Lưu ý: Có thể chọn biểu tượng
abc
để tạo nhãn

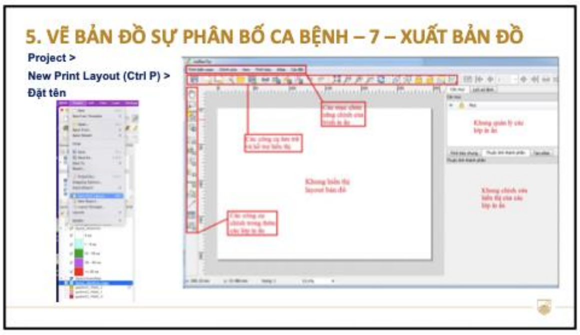

5. VẼ BẢN ĐỒ SỰ PHÂN BỐ CA BỆNH - 2
Hiển thị nhãn (Labels) cho bản đồ
THỰC HÀNH – 3
5 phút
• Hiển thị nhãn cho bản đồ (điều chỉnh font và màu chữ phù hợp)
• Thay đổi màu bản đồ

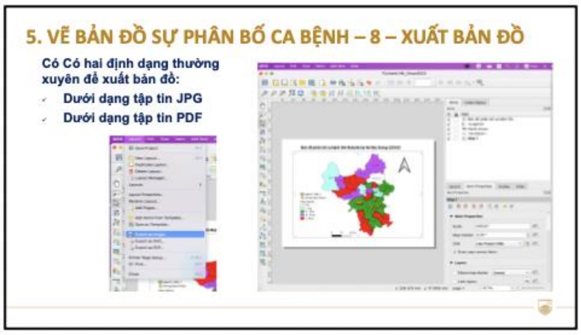

5. VẼ BẢN ĐỒ SỰ PHÂN BỐ CA BỆNH – 3 (Area map)
1
2
3
4
5
6

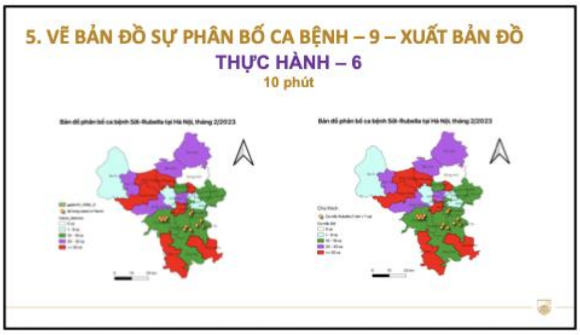

5. VẼ BẢN ĐỒ SỰ PHÂN BỐ CA BỆNH – 4 (Area map)
THỰC HÀNH – 4
5 phút


5. VẼ BẢN ĐỒ SỰ PHÂN BỐ CA BỆNH – 5 (Spot map)
Dữ liệu toạ độ không gian ca bệnh ở 1 file độc lập (*.CSV)
Điều kiện:
Cần có máy GPS định vị
Bản đồ hành chính cập nhật
Cmd + I (Data Source Manager)
Sử dụng file "lat long cases in Hanoi.csv"
4- LONG // 5- LAT


5. VẼ BẢN ĐỒ SỰ PHÂN BỐ CA BỆNH – 6 (Spot map)
THỰC HÀNH – 5
10 phút


5. VẼ BẢN ĐỒ SỰ PHÂN BỐ CA BỆNH – 7 – XUẤT BẢN ĐỒ
Project >
New Print Layout (Ctrl P) >
Đặt tên


5. VẼ BẢN ĐỒ SỰ PHÂN BỐ CA BỆNH – 8 – XUẤT BẢN ĐỒ
Có Có hai định dạng thường xuyên để xuất bản đồ:
Dưới dạng tập tin JPG
Dưới dạng tập tin PDF


5. VẼ BẢN ĐỒ SỰ PHÂN BỐ CA BỆNH – 9 – XUẤT BẢN ĐỒ
THỰC HÀNH – 6
10 phút


TÀI LIỆU THAM KHẢO
1. QGIS Documentation https://www.qgis.org/en/docs/index.html
2. QGIS Training Manual – QGIS Documentation : http://doc.qgis.org/2.14/en/docs/training_manual/
3. YouTube channel – (PGS.TS.Pham Quang Thai, 2023) https://www.youtube.com/watch?v=z7j3QVzbY_Q&list=PL4wcuB0inYYISx7CEwbSc0pSdxV_tJrFA
4. Hướng dẫn sử dụng phần mềm QGIS vẽ bản đồ dịch tễ bệnh truyền nhiễm, Viện Pasteur Nha Trang, 2022


Q & A
Australian National University
Huyen.Nguyen@anu.edu.au


Đánh giá buổi học
Thank you for your attention
Australian National University
https://anu.au1.qualtrics.com/jfe/form/SV_6RSk9CNyCNMp6DA

6.3.3 Lesson photos at the NIHE

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END OF THESIS

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