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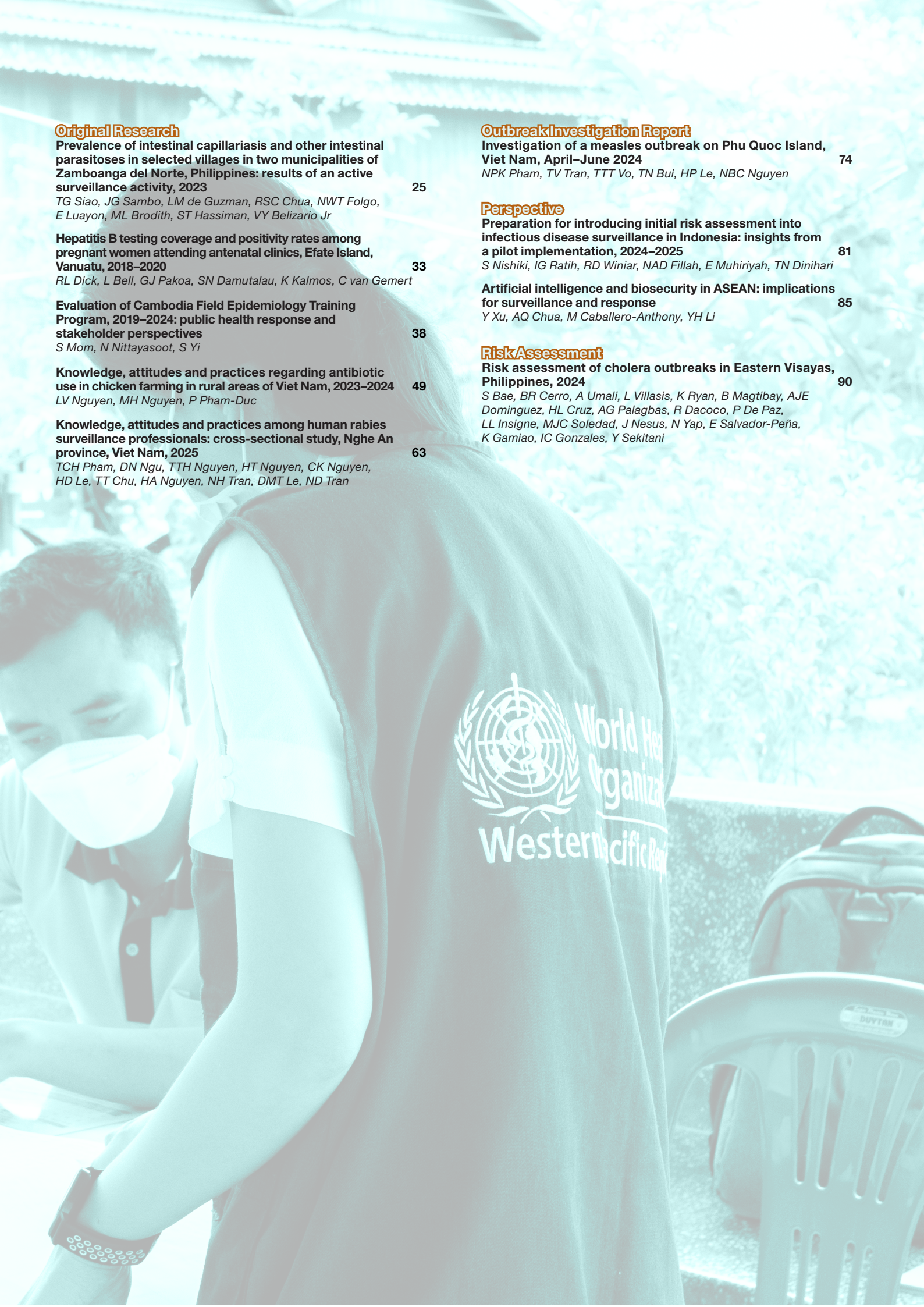
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Western Pacific Surveillance and Response

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Western Pacific Surveillance and Response
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Mpox intra-action review in the Philippines, 2025

Yui Sekitani,[a] Gloria Balboa,[b] Rowena Capistrano,[a] Judith Mariano,[b] Almira Gatchalian,[b] Liezl Fernandez,[b] Anne Dominique Matuba,[b] Anna Marie Celina Garfin,[b] Jose Gerard Belimac,[b] Angelica Mae Oira,[b] Soonjong Bae,[a] Princess Mhyco Esguerra,[a] Cling Malaco,[a] Kathleen E Ryan,[a] Juan Paolo Tonolete,[a] Kathleen Taylor Warren,[c] Wenyajing Zhang[c] and Sean T Casey[c,d]

Correspondence to: Yui Sekitani (email: ysekitani@who.int)

The Director-General of the World Health Organization (WHO) twice declared mpox (previously monkeypox) a public health emergency of international concern (PHEIC): first in July 2022 (ended May 2023) and again in August 2024 (ended September 2025).[1,2] A PHEIC triggers temporary recommendations under the International Health Regulations (2005) to coordinate global response.

On 18 August 2024, the Philippine Department of Health (DOH) confirmed its 10th case of mpox, following earlier detections in 2022 and 2023.[3] In response, the DOH established the Interim Mpox Task Force through Department Personnel Order No. 2024–5521 to lead the overall national response.[4] The Task Force comprised representatives from DOH offices, WHO staff and members of the DOH Emerging and Re-emerging Infectious Diseases Strategic Advisory Group of Experts (EREID-SAGE), with expertise in dermatology, infectious diseases, social science and genomics. The Task Force developed and published the 2024 Philippine Mpox National Action Plan in September 2024.[5]

In March 2025, the DOH, in collaboration with the WHO Representative Office for the Philippines and the Regional Office for the Western Pacific, conducted the first intra-action review (IAR) of a national mpox response in the WHO Western Pacific Region. The objective was to identify strengths, challenges and lessons learned from the 2022–2024 response.

PROCESS

In line with WHO guidance, the IAR[6] incorporated perspectives from national and regional health authorities, public health programme managers, emergency response teams, clinicians and affected communities. Participants were purposively selected to represent each of the six task groups of the Task Force: policy and planning, surveillance, risk communication and community engagement, access to biologics, clinical and public health management, and logistics and finance.

The IAR brought together a total of 69 participants, with the majority from the DOH Central Office, three from the Philippine National AIDS Council and the Food and Drug Administration, six from Centers for Health Development (regional health offices), two from a civil society organization (CSO) active in health interventions with key populations, and five EREID-SAGE members. Seven WHO staff served as facilitators. Data were gathered through focus group discussions structured around five questions adapted from the WHO IAR framework:

1. What was in place before the response?
2. What happened during the response?
3. What went well and what went less well?
4. What can be improved?
5. What are the ways forward?

[a] World Health Organization Representative Office for the Philippines, Manila, Philippines.
[b] Department of Health, Manila, Philippines.
[c] World Health Organization Regional Office for the Western Pacific, Manila, Philippines.
[d] Department of Public Health and Health Policy, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Japan.
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No individual structured interviews were conducted. Instead, a World Cafe method was used, involving rounds of discussion across groups, with participants rotating and building on the inputs of others. Discussion outputs were grouped based on the functions of the task groups, and priority actions were agreed through consensus during plenary sessions. **Table 1** presents the key findings, challenges and priority actions.

DISCUSSION

The mpox IAR included CSO representatives and scientific experts who may not typically be involved in national-level outbreak response coordination, broadening participation compared with the Philippines' COVID-19 after-action review in 2023.[7] That review involved multiple agencies but no community representatives. CSO participants representing key affected populations highlighted gaps in coordination between the DOH, medical societies and other CSOs. Strengthening these links is important for reaching at-risk populations, disseminating accurate health information and improving early detection.[8]

Overall, best practices and strengths during the mpox response were largely identified as deriving from lessons learned during the COVID-19 pandemic response. Following the IAR conducted in March 2025, and in the context of the broader response, the Philippines developed an updated Mpox National Action Plan for 2026–2028 and the TF structure. The establishment of the TF was identified as one of the key best practices, as it ensured a well coordinated and organized response effort through regular meetings and sustained engagement among members. This coordinated mechanism also facilitated the country's capability to mobilize access to medical countermeasures. In December 2024, the Philippines accessed Tecovirimat through the pooled procurement mechanism of the Association of Southeast Asian Nations (ASEAN).[9] Using available regulatory pathways including a compassionate special permit, a total of 160 full treatment courses were authorized and allocated to several DOH-designated hospitals. In February 2026, the Philippines also secured 2220 doses of live, non-replicating smallpox and mpox vaccine (MVA-BN, brand name JYNNEOS®) through the same ASEAN procurement channel.

The IAR was conducted during an ongoing health emergency, enabling real-time adjustments and continuous learning.[10] During the COVID-19 pandemic, an IAR identified similar coordination and data-sharing gaps across government agencies, suggesting these are systemic challenges and are not unique to the mpox context. Although mpox had faded from the headlines, the IAR provided an opportunity to help the DOH identify areas for improvement that are often overlooked in routine operations. It also promoted broader participation in health emergency responses. As emphasized by the mpox IAR, responses to dynamic and complex outbreaks require stronger coordination and more timely, interoperable data-sharing. It also highlighted the importance of adapting response strategies to at-risk populations, including leveraging existing systems such as HIV platforms, particularly for risk communication and community engagement, to ensure more inclusive and effective outreach.

This review had limitations. Although it brought together national and regional DOH offices, CSO representatives and scientific experts, providing a broad view of the mpox response, no local government units (LGUs) were represented. Given the role of LGUs in the decentralized Philippine health system, future IARs may further strengthen this approach by directly capturing LGU-level implementation experiences. Findings were based on self-reported experiences and may reflect recall and group discussion dynamics. The review did not include outcome data, such as case detection times or changes in transmission patterns, to measure the effect of the IAR on response performance. Thus, its findings may not be generalizable to other country contexts.

In conclusion, the Philippines' experience shows that inclusive, participatory IARs can bring together diverse groups to identify and review priorities, thereby strengthening coordination, communication and collaboration to improve response efforts. Importantly, the mpox IAR helped institutionalize the use of IARs as a regular component of emergency preparedness and response in the Philippines. Recognizing their value in improving multisectoral coordination, the Government has incorporated IARs as one of the key response strategies in the current National Action Plan for Health

Table 1. **Key findings, challenges and priority actions by task group function, Philippines, 2025**

Task group	Strengths/best practices	Challenges	Priority actions
Policy and planning	Technical guidelines on surveillance, screening, case management and infection control were developed in response to early mpox cases in Africa. Technical consultations with EREID-SAGE and the HIV Technical Working Group supported evidence-informed and context-specific guidelines.	DOH operated through vertical programme structures with limited workforce capacity. There was no formal policy for immediate data-sharing with subnational offices. Data privacy concerns and stigma were mentioned to affect contact tracing and public trust.	Develop and issue a policy to integrate EREID mechanisms and systems across programmes. Formalize inter-bureau and external data-sharing agreements and protocols to institutionalize coordination and response mechanisms.
Surveillance	Prior investments had already been made in systems strengthening and workforce capacity, including procurement for testing and training on specimen collection, operationalization of specimen collection guidelines and the development of an internal real-time national dashboard.	There were challenges in contact tracing, data verification and case tagging, as well as limited testing outside Metro Manila during the initial phase of the response. Data-sharing and dashboard access were limited for local government units and external stakeholders.	Strengthen and standardize laboratory human resource requirements and expand capacity-building efforts at subnational levels through a training-of-trainers approach. Incorporate mpox testing into the National Laboratory Strategic Plan. Enhance the dashboard and identify a more sustainable and interoperable reporting platform.
Risk communication and community engagement	A multisectoral approach was adopted to raise public awareness, support timely response, and strengthen social listening and infodemic management. Social media, town halls, CSO partnerships and medical society collaboration helped reach target audiences.	There were challenges related to sustaining inclusive messaging and combating stigma, low public awareness and limited access to trained health-care providers and health promotion practitioners at the community level.	Engage CSOs, medical societies, development partners and community champions as primary messengers to deliver trusted, evidence-based, timely, audience-appropriate information. Use diverse communication platforms to better reach target audiences.
Access to biologics	Active engagement with regional and global partners, including ASEAN and international health platforms, facilitated early access to information on vaccine development and pooled procurement mechanisms.	Delays in regulatory authorization for ASEAN-procured mpox vaccines limited timely access. Existing policy restricted emergency use authorization to COVID-19 vaccines and medications only.	Review and update policies on the importation and management of foreign-donated health products. Advocate for a general authorization pathway for non-COVID-19 emerging/re-emerging disease vaccines. Reactivate the National Immunization Technical Advisory Group to provide evidence-based guidance on outbreak response immunization.
Clinical and public health management	An established patient navigation and referral mechanism ensured continuity of care. Dermatologists and infectious disease specialists improved care pathways, as many cases sought consultation in private or sexual health clinics.	There was limited knowledge among some health-care workers on clinical care and supportive management.	Develop a Philippine mpox case atlas to share information. Strengthen feedback mechanisms and provide training on detection and case management with continued support from medical societies.
Logistics and finance	Response activities were financed through existing budget lines with additional allocations for critical supplies. A digital information system provided near-real-time inventory tracking and strategic augmentation of supplies such as personal protective equipment.	While funding was available, access mechanisms needed improvement. Subnational coordinators had limited capacity in commodity quantification and forecasting.	Conduct table-top simulation exercises to test guidelines and operational readiness. Facilitate coordination between technical and logistics offices to develop forecasting tools and improve warehouse management. Advocate for pre-positioning and dedicated EREID response funds.

ASEAN: Association of Southeast Asian Nations; CSO: civil society organization; DOH: Department of Health; EREID: Emerging and Re-Emerging Infectious Diseases; SAGE: Strategic Advisory Group of Experts.

Security, which was launched in May 2026, as well as the Emerging and Re-Emerging Infectious Diseases Strategic Plan 2026–2030. This integration reflects a broader commitment to systematically applying IARs to future public health threats and to enhancing public health responses during emergencies.

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Conflicts of interest

KTW and STC are associate editors of the *Western Pacific Surveillance and Response* journal. They were not involved in the editorial decision to publish this article. The other authors have no conflicts of interest to declare.

Ethics statement

This IAR was conducted as part of routine public health emergency management. It did not involve research on human subjects; therefore, ethical review board approval was not required.

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Achieving zero open defecation status through a community-based programme in Cavite, Philippines, 2013–2019: a field review

Julius R Migriño Jr,[a,b] Edroico Mari B Brillante,[a] Maria Cecil Elisa G Esguerra,[a] Orlie John Y Lavilla,[a] Juan Miguel Lorenzo C Milla[a] and Jennifer G Coritico[a]

Correspondence to Julius R Migriño, Jr (email: jrmjrmd-1@yahoo.com)

Problem: Open defecation is practised in several communities in the Philippines. Achieving zero open defecation (ZOD) certification in the Philippines has been shown to reduce disease burden and improve overall community health and well-being.

Context: Philippine communities are guided by the Department of Health to achieve ZOD status through verified municipal inspections. The Barangay Anahaw II administrative unit was selected as a site for implementing sustainable, community-based health programmes aimed at achieving ZOD.

Action: In 2013, a community diagnosis was conducted in the barangay to assess sanitation and health needs. In 2016, a multisectoral water, sanitation and hygiene committee, guided by a Community-Led Total Sanitation campaign, focused on improving the barangay's sanitation status and promoting behavioural change. By 2017, the campaign's activities had been implemented to prepare for and support ZOD verification and certification.

Outcome: The community diagnosis in the barangay identified improper waste management, including limited access to toilets, as one of its top health concerns. The community-led campaign included strategies such as household inspections, assessments of the knowledge of heads of households, clean-up drives and incentives to encourage toilet construction. While an initial attempt at certification in May 2017 was unsuccessful, the barangay achieved provincial ZOD certification in July 2019.

Discussion: A coordinated approach involving an initial community diagnosis, a multisectoral sanitation programme supported by local officials and the community, and continuing household engagement through activities and incentives enabled the achievement of ZOD certification.

PROBLEM

Open defecation is the practice of defecating in fields, forests, bodies of water or other open spaces.[1] This practice is a public health issue because people are exposed to human excreta, which often contaminates drinking-water, exposing communities to pathogenic faecal microorganisms, and consequently to diseases. According to the World Health Organization/United Nations Children's Fund (WHO/UNICEF) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene, although open defecation rates decreased between 2000 and 2024, there are still several countries, including the Philippines, that have not yet eliminated open defecation.[1]

According to WHO,[2] four major health outcomes are attributable to poor water, sanitation and hygiene (WASH): diarrhoea, acute respiratory infections, undernutrition and soil-transmitted helminthiases. At least 1.4 million lives lost in 2019 could have been prevented with the use of safe WASH services.[2] A study in Kenya demonstrated a significant difference in the prevalence of diarrhoea between subcounties where open defecation was and was not practised.[3] According to the 2022 Philippine National Demographic and Health Survey, approximately 3% of households in the country, and up to 18% of households in rural areas, still practised open defecation.[4] Ending open defecation by 2030 is a key outcome target of Sustainable Development Goal 6 (clean water and sanitation).[5]

[a] San Beda University, Manila, Philippines.
[b] School of Medicine and Public Health, Ateneo de Manila University, Pasig City, Philippines.
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CONTEXT

In the Philippines, local communities are classified into four sanitation levels: Grade 0 (open defecation), Grade 1 (zero open defecation), Grade 2 (basic sanitation) and Grade 3 (sustainable sanitation). Zero open defecation (ZOD), or Grade 1 status, is defined as a community wherein households have stopped practising open defecation and are using sanitary toilet facilities, and wherein no human faeces are openly visible or exposed to the environment.[6]

To reach ZOD status, seven criteria[6] must be achieved by the community: (1) open defecation is not practised; (2) 100% of households have access to sanitary toilets; (3) water and soap are available at or near toilets in all households; (4) excreta and diapers are disposed of properly; (5) a functional local government unit (LGU) coordinating body addresses WASH issues; (6) a local ordinance and a monitoring team help sustain ZOD status; and (7) an approved action plan or operational plan is in place and funding has been allocated to reach Grade 2 status. To be ZOD-certified, the community must pass several levels of verification, starting with a sanitary inspection by the rural health unit and moving up through municipal- and provincial-level certification.[7]

The province of Cavite is part of Region IV-A, in southern Luzon. Within Cavite, the municipality of Silang is a high-income, urbanizing municipality, classified as mainly agricultural and built-up areas. In 2020, its population was 295 644. The municipality is composed of 64 barangays (administrative units).

Barangay Anahaw II (BAII) in Silang (**Fig. 1**) consists of 768 households according to the 2015 census, with an average of 4.5 members per household. At least 80% of the families in BAII are classified as having income below the poverty threshold. Water is mostly provided by Silang Water District.

In June 2013, the San Beda University College of Medicine (SBU-COM) entered into a memorandum of agreement with Canossa Health and Social Center Foundation (CHSC), a Department of Health-recognized primary service institution situated in the barangay. The agreement aimed, in part, at developing sustainable community-based health programmes within BAII. The site was chosen from among 11 barangays in Silang due to its accessibility and readiness to take part in implementing such programmes. This study is a narrative analysis of the process of ZOD certification undertaken by BAII from 2013 to 2019.

ACTION

Community diagnosis

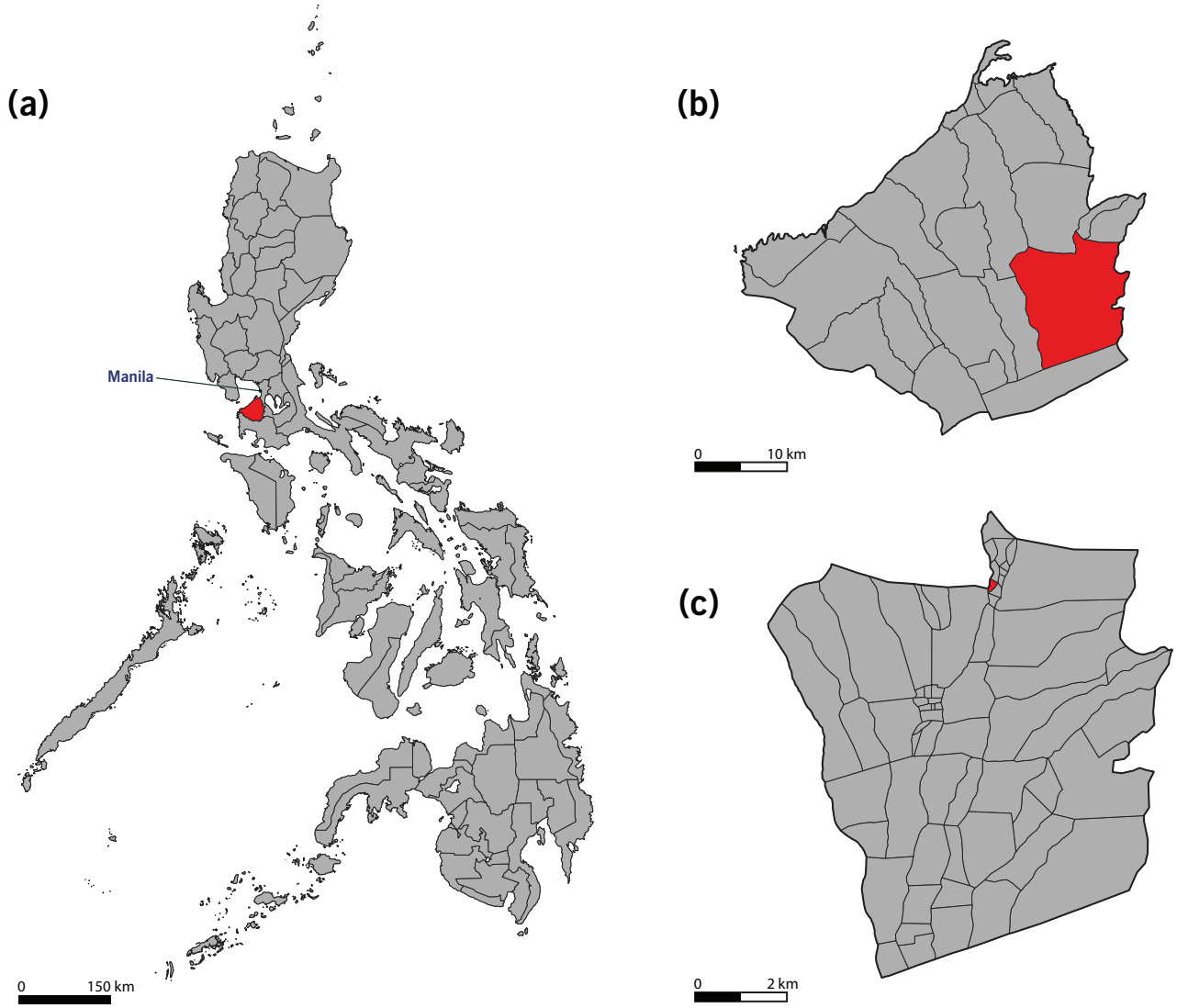
From June 2013 until March 2014, SBU-COM conducted a community diagnosis to assess the health needs of BAII. Health-related documents from the local rural health unit, containing health statistics about residents of the barangay, were reviewed, validated and correlated with the results of the community diagnosis. A total of 371 households were surveyed to determine their primary source of water, type of toilet facility, type of solid waste management and availability of basic sanitation facilities. Three barangay officials directly involved in health programmes were also interviewed by SBU-COM using structured interview guides to identify existing efforts to address sanitation issues in the barangay.

Community-led total sanitation

Starting in May 2016, SBU-COM, CHSC and barangay officials established the BAII Multisectoral WASH Committee. The Committee guided a Community-Led Total Sanitation (CLTS) campaign that specifically aimed to (1) upgrade the level of sanitation of the barangay from Grade 0 to Grade 1; (2) improve residents' sanitation and hygiene behaviours; and (3) educate residents about the health-related consequences of unsanitary practices.

An initial strategic plan was established by the Committee in October 2016, which included defining the roles and responsibilities of members, reviewing existing national and local sanitation laws, analysing the barangay sanitation situation and planning for specific campaign activities. Health education for heads of households was conducted by SBU-COM, CHSC and daycare teachers, while site visit validation of households without toilets was done by SBU-COM from October to December 2016. Additionally, a project called *Oplan Kubeta* ("Operation Toilet") was launched in October 2016 to raise funds for the construction of household toilets. The Committee, through the barangay captain, also conducted regular reviews to assess the progress of the CLTS campaign.

Fig. 1. **(a) Map of the province of Cavite, Philippines, highlighted in red; (b) map of the municipality of Silang within Cavite, highlighted in red; (c) map of Barangay Anahaw II within Silang, Cavite, highlighted in red**



Zero open defecation verification

In preparation for the ZOD verification processes, SBU-COM and CHSC conducted spot inspections of households from October to December 2016 to assess the knowledge of block leaders (volunteer members of a barangay block) about the components of household ZOD certification; additionally, a participation-based cash incentive system for block leaders was established. Block leaders were also trained as hygiene educators by SBU-COM.

The initial verification assessment was conducted in May 2017. As part of the verification process, households were inspected using a checklist that assessed each household's compliance with six sanitation requirements, ranging from the availability of soap and water to the proper disposal of different kinds of waste products (**Fig. 2**). Only households that fully met all six requirements passed the inspection. In December 2017, SBU-COM, CHSC and local officials launched the "4:30 PM habit," a daily reminder delivered through a WASH song played over the public announcement system, with the aim of conditioning community members to continue practising water conservation, better sanitation and good hygiene.

In March 2019, to ensure sustained segregation, collection and disposal of waste, the barangay coordinated with the Municipal Environment and Natural Resources Office. Waste segregation seminars and participation in the national cleanest barangay awards were among the

Fig. 2. **Barangay Anahaw II household inspection checklist, Philippines, 2013–2019**

APPENDIX IX

Revised Grading Sheet for House-to-House Inspection and Certification
Barangay Anahaw II House Sticker and Certification

Date:_____ Block No.:_____
Household No.:_____

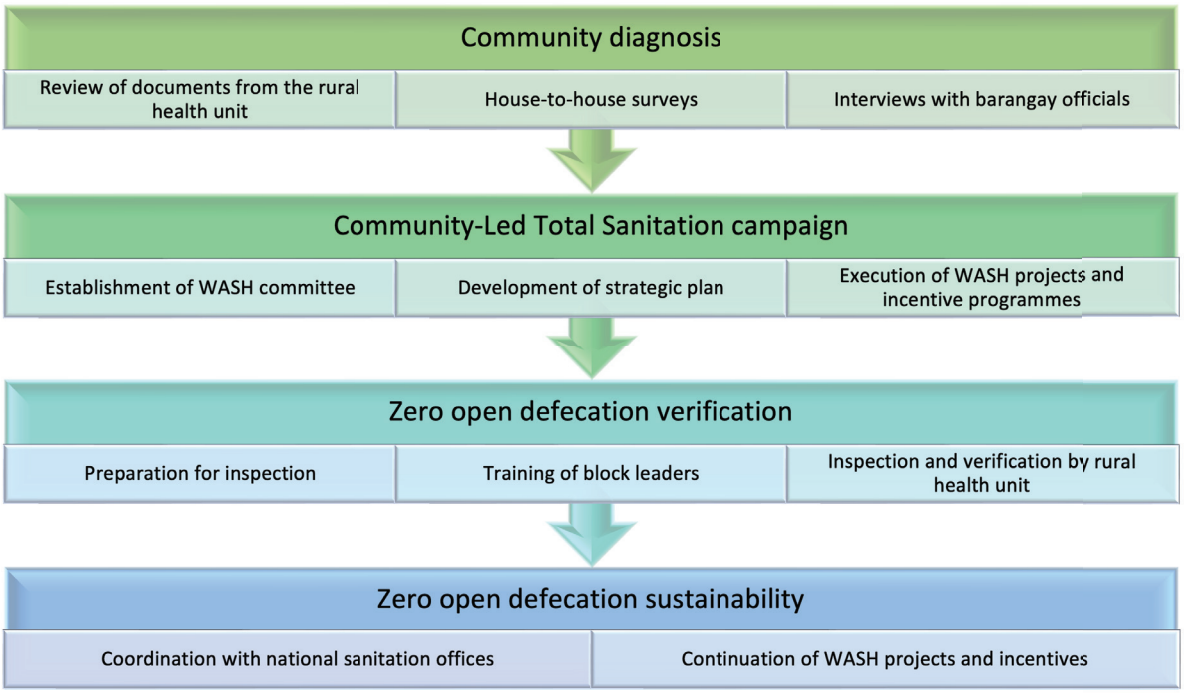
Availability of soap and water	**Grading**
1. No soap or water	1
2. Water only, no soap	2
3. Soap and water for handwashing	3
Proper disposal of diapers	
1. Thrown outside the house or thrown without wrapping	1
2. Individually wrapped and thrown in the wrong trash can	2
3. Excreta are flushed down the toilet or wrapped before thrown in the correct trash can	3
Proper disposal of sanitary napkins	
1. Thrown outside the house or thrown without wrapping	1
2. Individually wrapped and thrown in the wrong trash can	2
3. Covered with paper or plastic and thrown atin the correct trash can	3
Animal waste disposal	
1. Exposed outside or covered with soil in the walkway	1
2. Wrapped and thrown in other garbage	2
3. Excreta are flushed down the toilet or buried in the ground	3
Waste segregation	
1. No segregation	1
2. Biodegradable and non-biodegradable are segregated	2
3. Biodegradable, non-biodegradable, and recyclables are segregated	3
Proper food and water storage	
1. Food and water stored without cover	1
2. Food and water stored with cover	2
3. Food and water stored with cover, and dining and kitchen areas are clean	3
TOTAL	
Additional points (0, 1, 2)	
No trash littering the walkway	
No dog cages, backyard clotheslines, tarpaulin or awnings blocking the walkway	
No dog faeces, sanitary napkins or diapers littering the walkway	

Inspected/Certified by:_____

proposed strategies to sustain ZOD certification. The sustainability plans identified WASH Committee members as the responsible parties.

Fig. 3 summarizes the community-based sanitation programme processes conducted by SBU-COM, CHSC and BAII from 2013–2019 to achieve ZOD certification.

Fig. 3. **San Beda University College of Medicine, Canossa Health and Social Center Foundation and Barangay Anahaw II community-based sanitation programme, Philippines, 2013–2019**



WASH: water, sanitation and hygiene.

OUTCOME

The community diagnosis identified improper waste management as one of the key health-related concerns in the barangay. It revealed that 1% of households used pit latrines to dispose of human excreta, 6% did not have their own toilet, and 13% had a single toilet shared by about 10 people. Safe water was either insufficient or costly, worsening the barangay's sanitation situation. Interviews with barangay officials in 2014 revealed that efforts in the community primarily focused on proper waste segregation and collection, proper disposal of animal waste and unclogging of canals; no community programmes had been established to address open defecation.

The WASH Committee identified three problems as the focus of the CLTS campaign: (1) the need for behavioural change; (2) improper waste disposal; and (3) unavailability of toilets in some households. The committee also proposed several activities in the implementation of the campaign, such as recognition of house certification through the awarding of stickers, strict implementation of existing sanitation laws, weekly clean-up drives, conduct of community sanitation self-assessment activities, and development of incentive mechanisms to address the unavailability of toilets, such as by providing consultations and construction materials. Two households were also chosen to be beneficiaries of the funds from *Oplan Kubeta*.

The first round of verification assessments occurred in May 2017, and the barangay failed the verification process due to improper diaper disposal in 10% of the households visited. To prepare for the second round of verification, seven rounds of house-to-house inspections were conducted by the WASH Committee's hygiene educators from August to December 2017. During the inspection process, educators highlighted the six sanitation requirements evaluated by the checklist.

A second round of verification assessments occurred from November 2017 to April 2018. BAII passed the second verification and was qualified for ZOD certification from the rural health unit sanitary inspector. In May 2018, BAII was ZOD-certified by the Bulihan rural health unit and later certified at the municipal level. BAII was later provincially certified as having achieved ZOD status on 31 July 2019.

DISCUSSION

Initial community diagnosis is a crucial first step

The community diagnosis implemented as the initial step of the process was crucial for its success. As a result, the barangay acknowledged that waste management was an important health concern, which directly led to the CLTS campaign. It also showed that at the LGU level, there were no established programmes to address open defecation. Community diagnosis, undertaken with LGUs and private partners, can help generate information that guides informed public health planning, enabling prioritization of resources for more effective programmes.[8]

A multisectoral and collaborative programme was essential

The quick buy-in and direct involvement of local officials at all project stages also contributed to achieving ZOD certification. Active cooperation and participation of residents and ownership of the programme at the grassroots level also played crucial roles in the programme's success. It is essential to involve local stakeholders at every step of the process to ground the programme in the context of the community, which is in line with the WHO WASH framework,[1] local studies[9] and guidelines.[6] A similar finding about the importance of a multisectoral approach came from a 2025 study in Zamboanga del Norte.[10]

Incentives for improvement of sanitation facilities were also helpful in achieving ZOD certification. The barangay providing construction materials for sanitary toilets and enabling households to consult with construction workers contributed to the achievement of ZOD. Total sanitation campaigns similar to CLTS have been found to improve sanitation facilities in communities,[10,11] while improved sanitation leads to better community health outcomes.[2]

Continuous community engagement can facilitate certification

During the start of the project, a key challenge encountered was lack of participation by some households. A mid-project evaluation by SBU-COM showed that almost one third of the community was unaware of the CLTS campaign. This lack of awareness during the barangay's initial verification attempt may have contributed to its failure. Kagayan recommends that to achieve ZOD outcomes, a programme's aims and benefits to the community should be clearly articulated.[9] Different dissemination strategies may be effective in different contexts, such as policy briefs, social media and even consulting public relations experts.[12] Some of these strategies were implemented in this case, such as the 4:30 PM habit and household education sessions. Regardless of the strategies used, it is important to establish monitoring and evaluation systems to check an intervention's progress in meeting its goals, in this case to encourage behavioural change.

Access to infrastructure and facilities is also important to translate behaviours into practice.[13] Despite being situated in a high-income municipality, BAII is a rural community with limited financial resources. Additionally, the barangay's large population of low-income households and limited, costly and unreliable access to safe water were among other factors that may have hindered the initial ZOD initiative.[9,14,15]

Limitations

This study has several limitations. Some reviewed reports were anecdotal and lacked quantitative measures, which limited the analysis. This study was also limited in scope, focusing only on documents used and processes implemented to achieve ZOD certification; BAII's potential sanitation level progression from Grade 1 to Grade 2 was not reviewed due to shifts in the partnership's priorities. Finally, BAII's experience is specific to its context and may not be generalizable to other communities. It is recommended that similar programmes aimed at achieving ZOD status should develop both qualitative and quantitative metrics for monitoring and evaluation,[8] as well as assessing a community's specific contextual barriers, such as poverty, water supply costs and demographics, all of which are important determinants of success.[9,14]

Conclusions

The key lessons learned during BAII's ZOD certification process included (1) the importance of an initial community diagnosis, which identified improper waste management and limited access to toilets as priority sanitation concerns; (2) the need for a collaborative

sanitation programme that included the participation of private partners, local officials and residents; and (3) continuous household engagement throughout the verification process through activities such as knowledge assessments, clean-up drives and incentives. Similar communities can apply these general concepts, tailored to their own circumstances, resources and experiences to achieve ZOD status.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

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A pilot programme of community volunteers to improve hepatitis B medication adherence, Kiribati, 2025

Thomas Russell,[a] Caroline Lee,[b] Alice Lee[b] and David Hilmers[c]
Correspondence to David Hilmers (email: dhilmers@bcm.edu)

Problem: Antiviral therapy for chronic hepatitis B (CHB) reduces morbidity and mortality and improves quality of life. Achieving high levels of adherence is challenging due to multiple barriers, including medication fatigue, stigma, transportation and limited health literacy.

Context: Suboptimal adherence to antiviral therapy for CHB is problematic in Kiribati, particularly among high-risk groups including pregnant women and individuals with cirrhosis.

Action: During January–August 2025, a community volunteer intervention was initiated on Kiritimati, a remote island of Kiribati, to address adherence to CHB antiviral therapy. Community volunteers were assigned to patients positive for hepatitis B surface antigen who were commencing antiviral therapy and were pregnant or had cirrhosis. During home visits, volunteers provided education and encouraged medication adherence and clinic follow-up. Adherence in the intervention group was compared with adherence in positive patients being treated on other remote islands without the intervention.

Outcome: Adherence was measured by medication bottle counts. Outcomes were assessed by overall group adherence and individual adherence >80%. Group adherence was 77.4% (240.5/310.75) in the volunteer intervention group compared with 52.5% (700/1333) in the group without it ($P < 0.001$). Overall adherence among pregnant women in the intervention group was 89.7% (52/58). Individual adherence >80% was met in 58.8% (30/51) of the intervention group and 34.1% (70/205) in the control group ($P = 0.0012$).

Discussion: Although findings are preliminary and the intervention and control groups were not matched, this pilot suggests community volunteers are a promising intervention to improve CHB treatment adherence in a high-prevalence Pacific island setting. This strategy could also be explored for other chronic conditions where adherence is important.

PROBLEM

Chronic hepatitis B (CHB) is a significant global health concern affecting approximately 254 million people worldwide,[1] with sequelae of cirrhosis, liver failure and hepatocellular carcinoma (HCC). While effective antiviral medications are available to manage CHB, adherence to these treatments remains a significant challenge. Antiviral adherence is crucial for achieving and maintaining viral suppression and improving long-term outcomes and quality of life. Studies demonstrate that poor adherence to CHB medications can lead to treatment failure, viral resistance and increased risk of liver-related complications, including HCC.[2,3]

Multiple factors affect adherence to CHB antiviral therapy. The long-term nature of treatment, often lifelong, can lead to treatment fatigue and decreased motivation over time.[4] Absence of symptoms during early stages, lack of understanding about CHB and treatment, and side-effects (though usually mild) can also contribute to poor adherence.[5–7] The costs of treatment and transportation, family obligations and childcare, and stigma are additional factors.[7] Addressing social determinants of health is

[a] Department of Internal Medicine, Tungaru Central Hospital, Ministry of Health and Medical Services, Tarawa, Kiribati.
[b] Hepatitis B Free, Sydney, New South Wales, Australia.
[c] Departments of Internal Medicine and Pediatrics, Center for Space Medicine, Baylor College of Medicine, Houston, Texas, United States of America.
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critical to improving adherence rates. The objective of this project was to assess the feasibility and effectiveness of an innovative, volunteer-driven medication adherence pilot programme in a remote setting.

CONTEXT

Kiribati, a Pacific island nation with a high prevalence of hepatitis B (10–15%), implemented a national treatment programme in 2018.[8] Routine programme monitoring and interviews with health-care workers and patients identified medication adherence as a major challenge, particularly in critical populations such as patients with cirrhosis and pregnant women, in whom poor adherence can impact rates of HCC and vertical transmission. Based on clinic attendance rates, it was estimated that only 20% of all patients who started antivirals continued to take their medications as prescribed. Antiviral therapy is provided free of charge, but other factors such as family and caregiver responsibilities and limited health literacy are commonly cited by patients and local health providers as barriers to adherence. The cost of local transportation for patients to attend clinics and the need to maintain a consistent supply of medications across the vast geographical distances separating remote islands from the central pharmacy pose additional challenges. Systematic monitoring and implementation of strategies to improve adherence are essential in this resource-limited setting.

Addressing ongoing vertical transmission of hepatitis B is critical in Kiribati, given the persistently high prevalence of hepatitis B among children <5 years old (3%).[9] In addition to supporting robust birth dose and infant vaccination coverage, integration with antenatal care for pregnant women who test positive for hepatitis B surface antigen (HBsAg) and antiviral therapy per World Health Organization guidelines are important strategies to address high rates of vertical transmission.

ACTION

In January 2025, a community-level, health volunteer-driven pilot programme was initiated on Kiritimati, an outer island of Kiribati with a population of 7300. Individuals with CHB commencing antiviral therapy who were pregnant or diagnosed with cirrhosis (clinically or through transient elastography) were eligible. These groups were selected because prevention of vertical transmission and treatment of patients at high risk for progression are programme priorities.

The Ministry of Line and Phoenix Islands Development endorsed the project and its evaluation. Community volunteers (CVs) were recruited based on their interest in helping their community and proximity to patients in their villages. CVs received in-person training and ongoing telehealth support from a Kiribati physician. During a 1-day training session, CVs were instructed to provide basic education, to ensure that medications are taken and refilled, to counsel about side-effects and to facilitate clinic attendance. Emphasis was placed on accurately recording medication usage in a registry and developing positive relationships with patients. CVs transmitted monthly reports of their activities to the Kiribati physician. In addition to attending routine clinic appointments, pregnant women (n = 9) were visited weekly and patients with cirrhosis (n = 42) were visited monthly at home by volunteers. CV visits to pregnant women were scheduled more frequently because of the importance of adherence in preventing vertical transmission. CVs were paid 2 Australian dollars per visit. This programme began at the same time as an antiviral treatment programme on Kiritimati. All patients, whether assigned a CV or not, were naïve to antiviral therapy.

Patients were given 1 month (one bottle) of tenofovir alafenamide (TAF) at each clinic visit or, if unable to attend, by the CV during home visits. Adherence was calculated both by group and individually (**Box 1**). During home visits, CVs measured adherence through bottle counts.

Outcomes were group adherence, defined as the total number of bottles (months) consumed by the entire group divided by the total number of months that the individuals in the group had been on treatment. Individual adherence was defined as taking >80% of the prescribed medications during the period that the individual was on treatment. Individual adherence in each group was defined as the proportion of individuals in the group who had >80% adherence. Adherence was calculated on an intention-to-treat basis. Patients lost to follow-up were assumed to be non-adherent. For patients who died during the study period, adherence was based on the number of months on treatment until the month of death. For pregnant women, treatment time was calculated from the treatment start date until delivery.

Box 1. **Equations for treatment adherence calculations**

Group adherence $= \sum_{i=1}^{N} x\ taken_i \div \sum_{i=1}^{N} y\ treatment\ time_i$,

where *x taken* is in months (bottles) taken, and *y treatment time* is in months since treatment start.

Individual adherence $=$ *number of individuals taking >80% of medications ÷ number of individuals in group.*

At 6 months, an evaluation of programme effectiveness was undertaken to determine if the programme should be continued. Adherence (group and individual) in the volunteer intervention (VI) group was compared to that of CHB patients on treatment on other Kiribati outer islands (Abemama, Butaritari, Nonouti, Tabiteuea Maiaki, Tabuaeran and Teraina), where antiviral treatment had begun but the volunteer programme had yet to be implemented (NVI). Data from all patients from these islands whose adherence was assessed were used in the comparison. Adherence measurements were done through a patient registry of medication refills at outer island clinics. The total number of refills over the period since starting treatment was calculated for both the entire group and individuals (**Box 1**). A two-tailed *t*-test and a *Z*-test were used to analyse the differences in means and proportions, respectively. Differences were considered significant at $P < 0.05$. This comparison was not intended to be a formal clinical trial; rather, it is a progress report to inform policy-makers whether the programme is worthwhile to continue.

OUTCOME

From January to August 2025, the 51 patients in the VI group were followed by CVs on Kiritimati Island. Of these, nine were pregnant women and 42 were patients with cirrhosis (23 male, 19 female). Of those with cirrhosis, four died and five were lost to follow-up. The total number of treatment months for the VI group was 310.8, and 240.5 bottles of TAF were consumed, giving an overall adherence rate of 77.4% (**Table 1**). Within this group, the pregnant patients had an overall adherence of 89.7% (52/58 treatment months; data not shown). During a similar time frame, the NVI group ($n = 205$) had a total of 1332 treatment months, with 700 bottles consumed, yielding a group adherence of 52.6%. The difference in means between the two groups was significant via a two-tailed *t*-test ($P < 0.001$).

Regarding individual adherence, 58.8% (30/51) of patients in the VI group maintained >80% adherence, compared with 34.1% (70/205) in the NVI group ($P = 0.0012$). A high percentage (88.9%, 8/9) of the pregnant women in the VI group maintained adherence >80%. Because pregnancy status was not recorded in the NVI group, individual adherence among pregnant patients could not be compared between the two groups.

In conversations with the Kiribati physician, patients and volunteers expressed enthusiasm about participating in the project. Health-care workers, often nurses or

Table 1. **Characteristics and treatment adherence in volunteer and non-volunteer intervention groups of hepatitis B patients, Kiribati, 2025**

Variable	Group		*P*
	Volunteer intervention	No volunteer intervention	
Total no.	51	205	
No. (%) male	23 (45.1)	108 (52.7)	
No. (%) female	28 (54.9)	97 (47.3)	
Mean age (years)	39.4	37.8	
No. of months on treatment	310.8	1333.0	
No. of bottles consumed	240.5	700.0	
Group adherence (%)	77.4	52.5	<0.001
Individual adherence (%)	58.8	34.1	0.0012

medical assistants, anecdotally commented on the utility of the programme, as it seemed to improve clinic attendance, reduce complications and enhance clinic efficiency.

DISCUSSION

This pilot intervention suggests that CV support improves adherence to CHB antiviral therapy among high-priority groups of pregnant women and patients with cirrhosis living in a remote, low-resource setting on Kiritimati, Kiribati. CVs can potentially address several reasons for non-adherence, such as side-effects, misinformation, transportation issues, medication fatigue and stigma. Patient acceptance of the programme was enhanced by recruiting volunteers living in the same community who understand the challenges local patients face. To help patients with difficulties attending clinic, some CVs delivered medication to patients' homes. Pregnant patients had adherence rates approaching 90%. This may be attributed to more frequent visits (weekly) by the CVs and additional opportunities for education. Although a quantitative economic analysis was not performed, the project cost (roughly 100 Australian dollars per month) was small compared with the total hepatitis programme budget and the cost of hospitalizations due to CHB complications. The intervention costs could easily be recouped by preventing one maternally transmitted case of hepatitis with its associated lifelong health consequences. Improvements in adherence may have a significant impact on CHB mortality. A modelling study published in 2016 predicted that an increase in adherence from 65% to 95% would result in a 27% decrease in worldwide CHB mortality over 15 years.[10] Preventing new infections and the worsening of existing infections can avoid significant health costs caused by hepatitis-related morbidity and mortality.

There is limited research on strategies to improve adherence to CHB antiviral therapy in low- and middle-income countries (LMICs), including the impact of CVs.[11] Most data originate from HIV- and HCV-infected patients, and adherence is not a measured outcome. Li et al. performed a meta-analysis examining the role of community engagement and public health interventions on hepatitis outcomes.[12] They reported improvement of such programmes on HBV/HCV treatment adherence (relative risk: 1.14, 95% confidence interval: 1.03–1.27); however, data are sparse and mostly from high-income countries. Downs et al. described the efficacy of a peer support programme and its positive effects.[13] Other research in LMICs demonstrated that community supporters improved adherence to HIV antiretroviral therapy, especially in combination with text messaging.[14] Although more evidence is needed, these studies suggest the potential value of community-based interventions.

Our pilot project has several limitations. It was non-randomized, with a small sample and short study period. Because the pilot programme began concurrently with the initiation of antiviral treatment on Kiritimati, we did not have historical data to compare adherence in the VI group pre- and post-intervention. While the VI group included only pregnant women and people with cirrhosis, the NVI group included pregnant women and patients with and without cirrhosis. Patients without cirrhosis are likely to have fewer symptoms and are possibly less motivated to maintain adherence. Pregnant women may be more adherent to prevent transmission to their baby or less motivated if they have safety concerns about the medications. We were unable to make a direct comparison of adherence among pregnant women between the two groups because the duration of antiviral therapy for pregnant women in the NVI group was not recorded in the registry. Differences in local factors on other outer islands without the intervention programme may also introduce bias. For example, access to health facilities varies widely across the many islands included in the study. While they share a common language, the VI group is located in the Line Islands, thousands of kilometres from the Gilbert Islands where the NVI group resides, and some variations in regional customs and beliefs may exist. There is no gold standard measurement for CHB antiviral therapy adherence. We adopted a simple measure based on bottle counts, which is less precise than directly observed therapy or individual pill counts. To address these limitations, we plan to conduct a randomized trial over 12 months with larger, matched cohorts that are enrolled simultaneously. Future economic analysis may also help to quantify the economic benefits of such a programme. These studies may help guide policy-makers in developing strategies to improve adherence.

Our findings should be taken as preliminary and hypothesis-generating, rather than definitive evidence of effectiveness. Despite their limitations, the results demonstrate a promising innovation that may ameliorate barriers to CHB antiviral adherence in a low-resource

setting. Strong telehealth support and communication among the lead Kiribati physician, CVs and mid-level clinicians who provide most of the hepatitis care on the outer islands enabled continual feedback and rapid data-sharing. However, larger-scale implementation will require more resources. Our findings can potentially be generalized to other chronic diseases. A scoping review by Hassan et al. studied the effectiveness of community-based interventions for the management of chronic conditions in LMICs.[15] Facilitators influencing successful implementation outcomes included strong motivation among community health workers, high-quality training and role recognition for community health workers. Additionally, the presence of CVs from local neighbourhoods promoted positive interpersonal relationships, and assigning female CVs to pregnant patients produced positive gender dynamics.

Improved adherence can reduce vertical transmission, decrease hospitalizations, and lessen complications, including HCC and deaths. CHB patients commonly have comorbidities requiring medications, which could also be addressed during CV visits. Adherence is essential for other communicable and noncommunicable diseases, such as diabetes, hypertension and heart disease. Fostering a supportive health-care environment in the local community that reduces stigma, promotes education and encourages open communication can empower patients to adhere to their treatment.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

This volunteer project and its evaluation were endorsed by the Ministry of Line and Phoenix Islands Development. Ethical approval was not deemed necessary, as it was incorporated into routine programmatic delivery, and there was no difference in medical treatment provided to both groups. Participation in the programme was entirely voluntary for both patients and CVs.

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Strengthening post-disaster disease surveillance through field epidemiology support in Indonesia, 2025

Siti Shofiya Novita Sari,[a,b,c,d] Atik Choirul Hidajah,[a,b,d] Arief Hargono,[b,d] Mulianto[e] and Jontari[f]

Correspondence to Atik Choirul Hidajah (email: atik-c-h@fkm.unair.ac.id)

Problem: Natural disasters increase the risk of communicable disease transmission while disrupting routine disease surveillance systems, leading to delayed detection of outbreaks and weakened public health decision-making during emergency responses.

Context: Indonesia is vulnerable to natural hazards, and Aceh Province has experienced recurrent disasters with significant public health impacts. In late 2025, major flooding and landslides affected Aceh Tamiang District, disrupting health services. Field epidemiology support was deployed to strengthen post-disaster disease surveillance during the emergency response.

Action: A field epidemiologist strengthened case detection and registration at health posts, standardized disease recording, verified suspected clusters, and established centralized data compilation, analysis and situation reporting via the Health Emergency Operations Centre. Activities were aligned with World Health Organization functions and were adapted to emergency conditions.

Outcome: There was substantial disruption to routine health services, with severe damage to 12 of 15 primary health-care centres and the district health office, and moderate damage to two hospitals. Nevertheless, core surveillance functions were maintained during the emergency response, facilitating the reporting and documentation of multiple outbreak-prone diseases, including typhoid, measles and varicella. Surveillance outputs were used to inform timely risk assessment and response actions, including mobilizing laboratory surge capacity to support diagnostic activities.

Discussion: Concrete actions translate field data into timely, structured public health responses. Field epidemiologists can help maintain system functionality in resource-constrained emergencies by adapting to paper and mobile tools, synthesizing fragmented data and coordinating directly with laboratory personnel for case confirmation.

PROBLEM

Natural disasters substantially increase the risk of outbreaks of communicable diseases, particularly in the post-disaster period when water, sanitation and hygiene conditions may deteriorate and access to health services may be compromised. Natural disasters are frequently associated with outbreaks of waterborne and vector-borne diseases, while overcrowded living conditions in evacuation settings further amplify transmission risks.[1,2] Therefore, efficient disease surveillance is critical to early warning and to protecting against emerging infectious diseases during disaster response.[3]

However, during emergencies, routine disease surveillance systems are often disrupted due to damaged health facilities, limited human resources and competing response priorities.[4] In these circumstances, sustaining surveillance activities and ensuring the continuity of data flow to aid public health decision-making become major challenges. Despite their recognized importance, the

[a] Field Epidemiology Training Program, Universitas Airlangga, East Java Province, Indonesia.
[b] Division of Epidemiology, Department of Epidemiology, Biostatistics, Population Studies and Health Promotion, Faculty of Public Health, Universitas Airlangga, East Java Province, Indonesia.
[c] Airlangga Disease Prevention and Research Center – One Health Collaborating Center, East Java Province, Indonesia.
[d] Research Group of Epidemiology Integrated Intervention and Technology Collaboration, Universitas Airlangga, East Java Province, Indonesia.
[e] Aceh Tamiang District Health Office, Aceh Province, Indonesia.
[f] Public Health Laboratory Center of Banda Aceh, Aceh Province, Indonesia.
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specific operational contributions of field epidemiologists to post-disaster disease surveillance, particularly in low- and middle-income countries, remain inadequately documented in the scientific literature.[5,6]

CONTEXT

Field epidemiology is a core public health discipline that applies epidemiological methods to generate timely, actionable evidence for decision-making, particularly in settings where health systems are under pressure.[7] Field epidemiologists play a critical role in disease surveillance by detecting cases, reporting, analysing and interpreting health data, and translating surveillance findings into public health action. Their role is especially important in emergency and disaster settings, where routine health information systems may be disrupted.[5] During natural disasters, field epidemiology contributes to maintaining essential surveillance functions, enabling the early detection of outbreak-prone diseases and supporting evidence-based response activities.[8,9]

Indonesia is highly vulnerable to natural hazards, and provinces such as Aceh have experienced recurrent disasters that have had substantial impacts on infrastructure and population health. In late 2025, Aceh Tamiang District in Aceh Province was among the areas severely affected by major flooding and landslides that struck the island of Sumatra. International media reports described widespread destruction, large-scale population displacement and urgent humanitarian needs, with the broader disaster across Sumatra linked to more than 900 fatalities and significant disruption of essential services.[10]

In this context, the ability of field epidemiologists to adapt surveillance approaches, coordinate across sectors and synthesize fragmented data became crucial for protecting public health during the emergency response.

ACTION

During the emergency response, one field epidemiologist was deployed as part of a medical response team from Universitas Airlangga that also included clinicians and other public health personnel. The field epidemiologist was integrated into the district Health Emergency Operations Centre (HEOC) to support and coordinate surveillance activities. The entire medical response team, including the field epidemiologist, was deployed together for 12 days, from 8 to 20 December 2025, during the emergency response phase. Throughout this deployment, the operational activities of the field epidemiologist followed a clear chronological timeline. Initially, operations prioritized rapid situational assessments and the stabilization of fragmented, unstructured data transmitted via WhatsApp and paper records across evacuation centres. Mid-deployment, data collection was streamlined through the introduction of a centralized Google Forms database. In the final phase, this digitized mechanism facilitated systematic data verification, expedited daily situation reporting, and supported three preliminary epidemiological investigations (**Fig. 1**).

At the initial stage, the field epidemiologist operationalized case detection and registration protocols across health posts, evacuation centres and primary health-care facilities. They achieved this by identifying suspected cases using standard case definitions and distributing daily surveillance line lists to ensure data were systematically recorded. Priority communicable diseases were selected through rapid coordination within the HEOC and the District Health Office (DHO) based on their outbreak potential in post-flood settings (such as waterborne, vector-borne and vaccine-preventable diseases). Despite disruptions to routine services – including severe damage to 12 of 15 primary health-care centres and the DHO, as well as moderate damage to two hospitals – the field epidemiologist ensured the continuity of data collection at service points by introducing and distributing simplified, paper-based recording tools and the line list. This targeted action counteracted potentially severe disruptions to routine reporting systems caused by infrastructure damage and the loss of data systems at the DHO.

Due to the disruption of routine electronic surveillance systems, case data were initially recorded at health posts and evacuation centres using paper-based tools and simplified daily line lists. The field epidemiologist initiated and designed a Google Forms reporting system to structure the raw case reports that were shared via WhatsApp groups. The field epidemiologist distributed the submission links to field volunteers and was responsible for compiling data from WhatsApp reporting and Google Forms into a unified database. Through this integrated approach, the field epidemiologist maintained centralized data management at the HEOC and conducted daily analysis and interpretation of reported cases to monitor trends and identify priority diseases during the emergency

Table 1. **WHO core emergency disease surveillance functions operationalized by the deployed field epidemiologist during the disaster response phase, Aceh Tamiang, Indonesia, 2025**

WHO core surveillance function	Field epidemiology activities during the emergency response	Data source	Output produced
Case detection	Identified suspected cases at health posts using standard case definitions under disrupted service conditions	Health posts, primary health-care facilities	Records of suspected cases
Case registration	Simplified paper-based case recording and daily reporting using line lists due to disruption of electronic systems	Health posts, primary health-care facilities	Daily surveillance records and line lists
Case confirmation	Verified cases, conducted preliminary epidemiological assessment and coordinated specimen collection with the regional health laboratory in Banda Aceh	Health facilities, surveillance reports, laboratory teams	Investigation summaries and laboratory requests
Reporting	Compiled data from WhatsApp reporting and Google Forms for centralized reporting at the HEOC	Health facilities, surveillance officers	Consolidated surveillance database
Data analysis and interpretation	Conducted daily analysis of reported cases at the HEOC to monitor trends and identify priority diseases during the emergency response	HEOC surveillance database	Analytical summaries and alerts
Epidemic preparedness	Identified outbreak-prone diseases and supported preparedness for rapid response during the emergency phase	Surveillance and investigation outputs	Early warning alerts
Feedback	Disseminated surveillance findings through situation reports and coordination meetings	HEOC, coordination forums	Daily situation reports

HEOC: Health Emergency Operations Centre; WHO: World Health Organization.

Source: Adapted from WHO's Communicable disease surveillance and response systems: a guide to planning.[11]

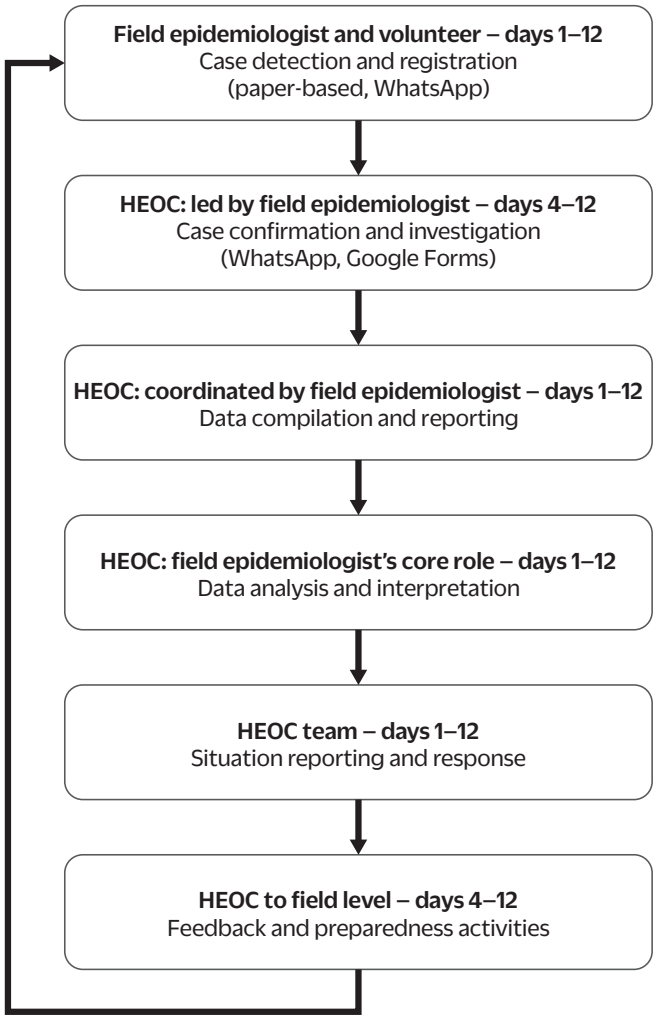
response. These surveillance activities followed World Health Organization (WHO) core surveillance functions and were operationalized during the emergency response (**Table 1**, **Fig. 1**).[11]

The deployed field epidemiologist supported case confirmation by conducting case verification and preliminary descriptive assessments of disease trends by person, place and time to identify potential clusters. The field epidemiologist strengthened epidemic preparedness by identifying outbreak-prone diseases and coordinating specimen collection with the Regional Health Laboratory of Banda Aceh for definitive diagnostic confirmation.

Routine data analysis was conducted at the HEOC, with the deployed field epidemiologist analysing surveillance data to identify trends and early warning signals of outbreak-prone diseases, thus contributing to epidemic preparedness in the post-disaster context. This analytical process enabled potential outbreaks to be identified and prioritized for response. After identifying warning signals, the field epidemiologist issued early notifications and conducted rapid risk assessments before laboratory confirmation, enabling a timely response to potential threats. Finally, to close the feedback loop, surveillance findings were disseminated through daily situation reports and coordination meetings by the Head of Disease Prevention and Control of the Aceh Tamiang DHO, as part of the HEOC team. This provided vital feedback to decision-makers and response actors, ensuring that surveillance data informed operational actions (**Table 1**).

Fig. 1 illustrates the integrated surveillance flow during the emergency response in Aceh Tamiang, showing how case detection at service points was linked to verification, centralized analysis at the HEOC, and situation reporting to guide coordinated public health responses and preparedness. The figure highlights the interconnected roles of field-level surveillance and centralized coordination in maintaining surveillance continuity under emergency conditions.

Fig. 1. **WHO core emergency disease surveillance functions during the disaster response phase in Aceh Tamiang, Indonesia, 2025**



HEOC: Health Emergency Operations Centre (district level).

OUTCOME

As a result of field epidemiology support during the emergency response phase, essential disease surveillance functions in Aceh Tamiang were sustained despite substantial disruption to routine health services. During the emergency response period from 8 to 20 December 2025, surveillance activities recorded a substantial number of communicable disease cases. The most frequently reported conditions were acute respiratory infections (n = 2774), acute diarrhoea (n = 1596), skin diseases (n = 1466) and influenza-like illness (n = 151). In addition, suspected cases of outbreak-prone diseases were identified, including typhoid fever (n = 72); measles (n = 13); varicella (n = 10); dengue (n = 5); pulmonary tuberculosis (n = 4); hand, foot and mouth disease (n = 3); leptospirosis (n = 3); and pertussis (n = 1). At the HEOC, the field epidemiologist systematically compiled, verified and analysed these incoming data, enabling the ongoing monitoring of communicable disease trends.

Active surveillance facilitated the notification of several outbreak-prone diseases through routine reporting mechanisms. The field epidemiologist directly coordinated the verification and risk assessment processes at the district level and led three field epidemiological investigations, specifically targeting suspected cases of measles, varicella and leptospirosis. These cumulative efforts successfully established a structured reporting system and initiated data verification to serve as a potential operational reference for future emergency responses.

The field epidemiologist synthesized surveillance findings and produced daily situation reports that were communicated to relevant stakeholders. These reports were shared during coordination meetings and used to inform response activities, including the mobilization of laboratory surge capacity. Overall, surveillance activities were maintained across core functions during the emergency response, including case detection, verification, data analysis and reporting, enabling continuous monitoring of communicable disease risks in the post-disaster setting.

DISCUSSION

The activities of the field epidemiologist enabled the continuation of core disease surveillance functions in Aceh Tamiang despite significant disruption to routine health services caused by flooding. By being integrated within the HEOC, the deployed field epidemiologist helped to adapt surveillance processes to the post-disaster context by transitioning unstructured WhatsApp reports into a centralized Google Forms database. This adaptation ensured that the system remained functional, allowing for the timely detection and notification of outbreak-prone diseases. Importantly, the field epidemiologist contributed to maintaining minimum surveillance standards under emergency conditions by sustaining verification, analysis and structured reporting functions, ensuring that surveillance data were rapidly translated into situation reports and coordinated public health actions.[12,13]

Building on this continuity, surveillance activities during the emergency response were implemented across core functions. The linkage between field-level data generation and centralized compilation and analysis at the HEOC facilitated the maintenance of structured surveillance processes under disrupted conditions (**Table 1**, **Fig. 1**). This highlights the importance of being able to adapt surveillance systems, as demonstrated by the simplified use of reporting mechanisms (paper-based tools, WhatsApp and Google Forms), and the continued detection of communicable diseases during the 12-day emergency response period. This observation is consistent with WHO guidance, which emphasizes that fragmented surveillance systems in post-disaster settings can delay outbreak detection and weaken response effectiveness.[11]

As a result of this integrated surveillance system, multiple outbreak-prone diseases were identified, reflecting active surveillance during the emergency response to support coordination and response activities. This finding aligns with literature highlighting the potential for risks from communicable diseases in post-disaster settings.[2] However, without comparative baseline data, these findings do not facilitate conclusions to be drawn about changes in disease transmission. Instead, they reflect the continuation of routine surveillance activity under emergency conditions, underscoring the importance of sensitive surveillance systems for early outbreak detection.[14]

Central to enabling the management of this early warning and response system was the integration of the deployed field epidemiologist within the HEOC, which functioned as a surveillance and decision-making hub. By supporting data compilation and analysis, outbreak notification and coordination, the field epidemiologist enhanced situational awareness during the emergency response. Centralized analysis and routine situational reporting facilitated the translation of surveillance data into timely operational decision-making and coordinated public health action.[15]

This linkage between surveillance and response was further demonstrated by how surveillance outputs triggered immediate field investigations (such as the rapid case verification of suspected measles and leptospirosis), informing concrete public health actions through mechanisms for routine reporting and coordination, and highlighting the importance of integrated surveillance systems in guiding timely and appropriate emergency responses.

This study has several limitations. The absence of baseline surveillance data limited the assessment of changes in disease incidence following the disaster. Surveillance under emergency conditions, with limited resources and damaged infrastructure, may have affected data completeness and timeliness. Simplified reporting mechanisms may also have introduced inconsistencies in data recording and transmission. Additionally, coordination challenges affected case classification, from the intermittent availability of networks to delays in confirmation caused by non-operational local laboratories to the more than 24 hours required to transport samples over land to the provincial laboratory.

Additionally, this report reflects the experience of a single district and may not be generalizable to other settings. Underreporting may have occurred during the acute emergency phase due to disruptions in access to health services and reporting systems; for example, the total number of active reporting sites and reporting completeness were not consistently documented. In addition, as this study was conducted by the deployed field epidemiologist, there is a potential risk of positive reporting bias in the interpretation of findings. Despite these limitations, adaptive strategies were implemented to maintain surveillance continuity during the emergency response, providing practical insights for similar settings.

Taken together, these operational experiences illustrate the vital role of field epidemiology in sustaining surveillance functions during disaster response in real-world emergency settings. The experience from Aceh Tamiang, including surveillance activities conducted during the emergency deployment using simplified reporting mechanisms, is particularly relevant for other disaster-prone low- and middle-income countries, where routine surveillance systems are often disrupted. This study highlights approaches for integrating field epidemiology into post-disaster disease surveillance and response.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

This article is based on operational surveillance activities conducted during an emergency response and did not involve the collection of individual-level data or the use of human or animal samples. Ethical approval was, therefore, not required.

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Prevalence of intestinal capillariasis and other intestinal parasitoses in selected villages in two municipalities of Zamboanga del Norte, Philippines: results of an active surveillance activity, 2023

Taggart G Siao,[a] Jenelle G Sambo,[a] Lorenzo M de Guzman,[a] Rupert SC Chua,[a] Neo WT Folgo,[b] Eduardo Luayon,[c] Mark Lindo Brodith,[d] Shaheeda T Hassiman[e] and Vicente Y Belizario Jr[a,f]

Correspondence to Taggart G Siao (email: taggartsiao@gmail.com)

Objective: In countries such as the Philippines where the consumption of raw fish is common, fish-borne helminthic diseases such as heterophyidiasis and capillariasis are a particular concern. This study aimed to investigate the prevalence of capillariasis and other intestinal parasitoses in two municipalities in Zamboanga del Norte province, Philippines, using a proposed set of selection criteria for active case finding.

Methods: Villages were selected for active case finding using the following criteria: proximity to a body of freshwater; reports of residents with chronic diarrhoea, abdominal pain or discomfort; reports of the consumption of raw or insufficiently cooked freshwater fish by residents; and reported cases of intestinal capillariasis in the past 3 years. Study participants were patients with a history of consuming raw or undercooked fish, diarrhoea lasting more than 2 weeks, or abdominal pain or discomfort. Stool samples were examined using a direct faecal smear and modified Kato-Katz technique.

Results: The prevalence of capillariasis among the 235 study participants was 7.2%. The highest prevalence was seen in males aged 19–45 years. The prevalence of soil-transmitted helminthiasis was 16.2%; schistosomiasis, 2.1%; heterophyidiasis, 2.6%; taeniasis, 1.7%; and intestinal protozoan infections, 1.3%. An incidental finding of paragonimiasis was seen in one participant.

Discussion: Intestinal capillariasis remains a public health challenge in Zamboanga del Norte, underscoring the need for active surveillance and early diagnosis of capillariasis and other foodborne helminthiases in areas where the consumption of raw or undercooked fish is common. The selection criteria for case finding used in this study may be further refined and tested to provide the basis of an active surveillance protocol for these diseases.

The global burden of foodborne diseases is considerable, driven by a variety of causative agents, such as bacteria, viruses, protozoa, helminths and chemicals.[1] Foodborne helminthiases (FBHs) are a group of parasitic infections acquired through the consumption of raw or undercooked fish, crustaceans, molluscs, meat and vegetables.[2] Although morbidity and mortality associated with FBHs are of significant public health concern,[3,4] most foodborne helminthic parasitic diseases, such as foodborne trematodiasis (FBT), taeniasis and cysticercosis, are not notifiable diseases. Estimates of the burden of foodborne parasitic diseases are thus limited. According to World Health Organization (WHO) estimates, which draw on systematic reviews and data from expert consultations, FBT infections are associated with the loss of 1 875 000 disability-adjusted life-years (DALYs) globally; *Taenia solium* alone is associated with the loss of 514 000 DALYs each year.[1]

[a] Neglected Tropical Diseases Study Group, National Institutes of Health, University of the Philippines, Manila, Philippines.
[b] Department of Health, Zamboanga Peninsula Center for Health Development, Zamboanga City, Philippines.
[c] Provincial Health Office, Zamboanga del Norte, Philippines.
[d] Rural Health Unit – Municipality of Jose Dalman, Zamboanga del Norte, Philippines.
[e] Rural Health Unit – Municipality of President Manuel A Roxas, Zamboanga del Norte, Philippines.
[f] College of Public Health, University of the Philippines, Manila, Philippines.
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However, as foodborne parasitic diseases are localized to specific geographical areas[5] and often associated with poverty,[3] global estimates mask the high disease burden experienced by some countries and local communities. Furthermore, evidence is emerging that the prevalence of some FBHs, including taeniasis, heterophyidiasis and capillariasis, has increased over the past few decades.[4]

Intestinal capillariasis infection is endemic in the Philippines, Thailand and other parts of Asia.[6] Clinical signs and symptoms include malabsorption accompanied by diarrhoea and abdominal pain. Suspected unconfirmed cases of capillariasis have been reported in the province of Zamboanga del Norte, Philippines, since 1999,[7] and outbreaks were declared in the province between 2006 and 2016.[8] Following the 2016 outbreak, the Zamboanga Peninsula Center for Health Development conducted a combined capacity-building and active surveillance activity in collaboration with the University of the Philippines Manila. It was found that in both the municipalities of Jose Dalman and Siayan, 24.1% of samples were positive for capillariasis. In Sindangan and Manukan, the proportion of positive samples was 12.3% and 3.0%, respectively. In the prior 4 years, 38 deaths were attributed to capillariasis in Jose Dalman (Jose Dalman Rural Health Unit, personal communication, 2023). Cases of capillariasis have also been reported in the municipality of President Manuel A Roxas (Pres Manuel A Roxas Rural Health Unit, personal communication, 2023).

In the Philippines, responsibility for the control of FBHs lies with the Food- and Waterborne Disease Prevention and Control Program (FWBD-PCP), which defines them as "including but not limited to heterophyids, *Taenia* sp., *Capillaria* sp. and *Paragonimus* sp.".[9] The programme is delivered through the environmental health unit and has responsibility for all food- and waterborne diseases caused by bacteria and viruses as well as other parasites. Given its wide remit, FWBD-PCP operates mainly as a preventive sanitation programme and its resources focus on achieving its goal of achieving zero open defecation (that is, all households in the Philippines have access to sanitary toilets).[9] This has meant that other control strategies, such as active surveillance and health promotion and education, have generally received less attention. Diagnosis of capillariasis and other FBHs has, therefore, largely relied on passive surveillance. However, for many people living in more remote rural locations, care-seeking can entail considerable land travel and prohibitive cost. Rural health units have periodically provided free diagnosis and treatment to indigent people living in remote capillariasis-endemic villages.

Active surveillance is a strategy that provides the opportunity for early diagnosis and treatment of infectious diseases and has been shown to contribute to reduced morbidity and mortality due to food- and waterborne diseases.[10,11] However, an accurate surveillance and mapping methodology for FBHs is still lacking.[9] Drawing on previous research and a review of global and national policies on FBTs, taeniasis, cysticercosis and other FBHs, we developed a set of criteria for selecting villages and patients for active case finding that could be implemented as part of an active surveillance programme for capillariasis. The aim of this study was to describe the outcome of a surveillance activity to investigate the prevalence of capillariasis and other intestinal parasitoses in selected municipalities in Zamboanga del Norte, Philippines, which was conducted using our proposed selection criteria.

METHODS

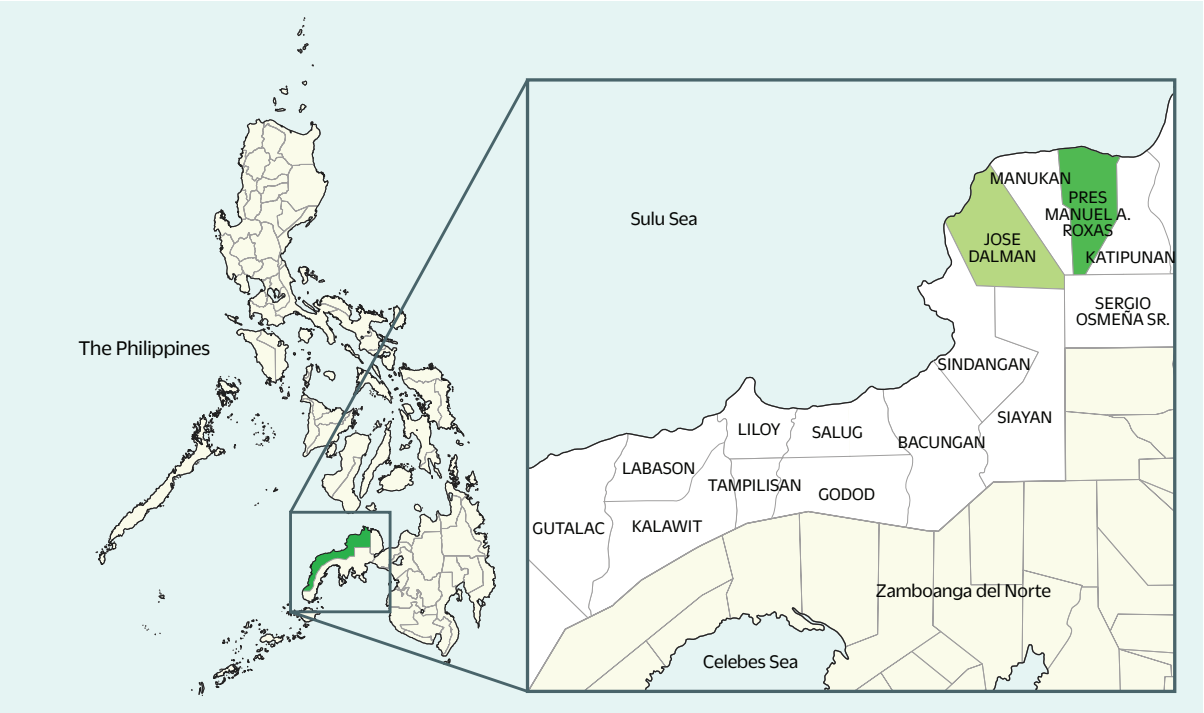
Study sites and participants

Zamboanga del Norte is a province located on the island of Mindanao comprising 25 municipalities, several of which are known to be endemic for capillariasis, including Jose Dalman and Pres Manuel A Roxas (**Fig. 1**).[12]

Pres Manuel A Roxas municipality has 33 villages, six of which are found along coastal areas. Three main bodies of freshwater, namely the Piao River, Tanian River and Dohinob Banay River, pass through its territory. In 2018, the poverty incidence was 55.6%, well above the national average of 16.7%.[13] Fishing and fishing-related industries are the main sources of income.[14] Jose Dalman, with 18 villages, is another coastal municipality with similarly high levels of poverty (56.5%).[13] The local economy is mainly agricultural, with corn and coconut being the major products.[14] The majority of the population belongs to the Subanen Tribe, a riverine local indigenous group whose culture includes the consumption of raw fish, prawn or chicken innards (locally known as "kinilaw") paired with coconut wine or vinegar.[15]

Newly developed criteria designed to target communities highly likely to have cases of capillariasis

Fig. 1. **Study sites: municipalities of Jose Dalman and President Manuel A Roxas, Zamboanga del Norte province, Philippines**



Source: PhilAtlas.[12]

were used to select study sites and participants for active surveillance. Villages were chosen based on the following criteria: (1) proximity to a body of freshwater; (2) reports of residents with chronic or recurring diarrhoea (watery or soft stool), and/or abdominal pain or discomfort; (3) residents self-reporting the consumption of raw or insufficiently cooked freshwater fish; and (4) reported cases of capillariasis in the past 3 years. Evidence of reported cases was based on a review of medical records and case confirmation by authorities such as the Department of Health, the Research Institute for Tropical Medicine or the University of the Philippines Manila. Based on these criteria, nine villages located near rivers were selected for study, of which three were in Pres Manuel A Roxas (Gubat, Situbo and Salisig) and six were in Jose Dalman (Balatakan, Bitoon, Lipay, Lumaping, Marupay and Tamarok).

The parasitological assessment was conducted during April 2023. Study participants were identified by village health workers (VHWs) using the following inclusion criteria: (1) people with a history of consuming raw or undercooked fish; (2) people with diarrhoea lasting more than 2 weeks; and/or (3) people having abdominal pain or discomfort within 30 days of the start of the assessment. Participants meeting these criteria were invited to provide a stool sample for analysis. Informed consent was obtained by trained research staff. Patients who were diagnosed with capillariasis during the surveillance activity were interviewed by the study team to determine whether members of their family and social circles were experiencing similar symptoms. Contacts who reported symptoms were also requested to submit a stool sample for microscopic examination.

Laboratory diagnosis and treatment

Stool samples were prepared for microscopic examination using a combined direct faecal smear (DFS) and modified Kato-Katz technique within 24 hours of collection.[16] Prepared slides were examined for soil-transmitted helminths, *C. philippinensis, Taenia* sp., heterophyid and other FBH ova, and intestinal protozoan cysts or trophozoites. While DFS can detect both helminthic and protozoan infections, its sensitivity for diagnosing helminthic infections is relatively low; the modified Kato-Katz technique only detects helminthic diseases, but with a higher sensitivity.[16] For quality control, medical technologists were trained in the diagnosis of intestinal parasitoses before conducting the active surveillance

Table 1. **Prevalence of capillariasis by age group and sex, in the municipalities of Jose Dalman and Pres Manuel A Roxas, Zamboanga del Norte province, Philippines, December 2022 to April 2023**

Age group, years	Total		Male		Female	
	n	No. (%) positive for capillariasis	*n*	No. (%) positive for capillariasis	*n*	No. (%) positive for capillariasis
10–18	24	1 (4.2)	17	1 (5.9)	7	0
19–45	104	13 (12.5)	60	8 (13.3)	44	5 (11.4)
46–65	95	3 (3.2)	50	2 (4.0)	45	1 (2.2)
>65	8	0	5	0	3	0
Unknown	4	0	2	0	2	0
Total	**235**	**17 (7.2)**	**134**	**11 (8.2)**	**101**	**6 (6.0)**

activity. Reference microscopists performed immediate verification of parasite ova, cysts or trophozoites to confirm a diagnosis. In addition, electronic images of parasite ova were taken for verification by experts in the Department of Parasitology, College of Public Health, University of the Philippines Manila. All positive slides and 10% of negative slides were re-examined by a reference microscopist who was blinded to the initial results.

All individuals with positive results for parasitic infections were treated with 400 mg albendazole for 10 days, in accordance with WHO guidelines.[17]

Data processing and analysis

Results of parasitological assessment were double-encoded using Microsoft Excel, and data were validated by the data manager. Prevalences of intestinal capillariasis and other helminths by age group, sex and village were calculated as the number of patients who tested positive as a percentage of the number of patients examined.

RESULTS

Parasitological assessment

A total of 235 study participants submitted stool samples for processing and examination. No one declined to provide a stool sample. As shown in **Table 1**, the overall prevalence of capillariasis among study participants was 7.2%. The highest prevalence levels were seen in people aged 19–45 years (12.5%); within this age group, prevalence was significantly higher in males (13.3%) than in females (11.4%; $P = 0.044$). The median age of those diagnosed with capillariasis was 37 years (interquartile range: 24–54); the age range was 10–59 years.

In Jose Dalman, the prevalence of capillariasis among study participants averaged 7.1%. The village of Lipay had the highest prevalence at 26.3% (**Table 2**). The prevalence of capillariasis among study participants averaged 7.8% in Pres Manuel A Roxas, ranging from 6.3% in Gubat to 9.1% in Situbo (**Table 2**).

Other intestinal parasites were also found, as shown in **Table 2**. The prevalence of soil-transmitted helminthiasis (STH) was 16.2%, schistosomiasis was 2.1%, heterophyidiasis was 2.6%, taeniasis was 1.7% and intestinal protozoan infections was 1.3%. An incidental case of paragonimiasis was also seen and referred to the rural health unit for appropriate treatment.

In Jose Dalman, heterophyidiasis, taeniasis and intestinal protozoan infections were seen in 3.3%, 1.6% and 1.6% of stool samples, respectively. The prevalence of STH was moderate at 13.6%, with the highest prevalence in the village of Tamarok (32.0%), followed by Lipay (26.3%) and Marupay (25.0%). Cases of schistosomiasis were seen in the villages of Bitoon and Lumaping, with a prevalence of 3.6% and 4.9%, respectively. The prevalence of STH was higher in Pres Manuel A Roxas (25.5%); Gubat and Situbo reported prevalences of 25.0% and 27.3%, respectively, while Salisig had no cases. Other than an isolated case of taeniasis, no other intestinal parasitic infections were seen in Pres Manuel A Roxas (**Table 2**).

Table 2. **Prevalence of FBH, STH, schistosomiasis and protozoan infections in selected villages in the municipalities of Jose Dalman and Pres Manuel A Roxas, Zamboanga del Norte province, Philippines, December 2022 to April 2023**

Municipality/ village	No. of patients examined	No. (%) positive for FBH				No. (%) positive for any STH	No. (%) positive for schistosomiasis	No. (%) positive for protozoans (*Endolimax nana*, *Escherichia coli*, *Giardia* sp.)
		Capillariasis	Heterophyidiasis	Taeniasis	Paragonimiasis			
Jose Dalman	**184**	**13 (7.1)**	**6 (3.3)**	**3 (1.6)**	**1 (0.5)**	**25 (13.6)**	**5 (2.7)**	**3 (1.6)**
Balatakan	20	0	0	0	0	2 (10)	0	1 (5.0)
Bitoon	55	1 (1.8)	1 (1.8)	1 (1.8)	0	5 (9.1)	2 (3.6)	0
Lipay	19	5 (26.3)	0	0	0	5 (26.3)	0	0
Lumaping	61	5 (8.2)	4 (6.6)	1 (1.6)	0	4 (6.6)	3 (4.9)	1 (1.6)
Marupay	4	0	1 (25.0)	0	0	1 (25.0)	0	0
Tamarok	25	2 (8.0)	0	1 (4.0)	1 (4.0)	8 (32.0)	0	1 (4.0)
Pres Manuel A Roxas	**51**	**4 (7.8)**	**0**	**1 (2.0)**	**0**	**13 (25.5)**	**0**	**0**
Gubat	16	1 (6.3)	0	0	0	4 (25.0)	0	0
Situbo	33	3 (9.1)	0	1 (3.0)	0	9 (27.3)	0	0
Salisig	2	0	0	0	0	0	0	0
Total	**235**	**17 (7.2)**	**6 (2.6)**	**4 (1.7)**	**1 (0.4)**	**38 (16.2)**	**5 (2.1)**	**3 (1.3)**

FBH: foodborne helminths; STH: soil-transmitted helminthiasis.

DISCUSSION

This study reassessed the burden of capillariasis and other intestinal parasitoses in Zamboanga del Norte province, Philippines, 7 years after the last major reported outbreak in 2016. We found a lower prevalence of capillariasis overall, relative to the 2016 outbreak (7.2% vs 24.1%). Nevertheless, our study demonstrates that FBHs are still a public health concern in some communities. In some villages, capillariasis prevalence was more than 10%, a level that may be considered relatively high. Prevalence was highest in young adult males (19–45 years), a pattern that is consistent with previously published literature.[18–20] High levels of capillariasis may be attributed to the continued consumption of *kinilaw* along with alcoholic beverages during social activities, and continued open defaecation in the affected communities.[18–21]

Belief in cultural explanatory models of disease causation, such as *kulam* (witchcraft), has been documented in the study sites and is suggested as a possible cause of delays in seeking diagnosis and treatment. For example, the Subanen or Subanon people often attribute intestinal capillariasis to *buyag* – an affliction brought about by dishonouring the nature spirits[15] – and thus favour using local supernatural remedies to treat their symptoms before or while simultaneously consulting health professionals. Typically, upon onset of symptoms, patients self-medicate with herbal concoctions and then consult an *albularyo, mananambal* or *balyan* (witch doctor); if symptoms persist, they would consider consulting a health worker. Studies have also shown that local Subanons associate substantial financial burden with capillariasis, citing expenses, loss of income and the inability to work as other possible reasons for delays in consulting a health professional.[15] Culturally appropriate and sensitive health communications that address misconceptions regarding the transmission, prevention and control of capillariasis and emphasize the need to consult a health professional sooner when symptoms occur may help to improve health literacy and the management of health risks.[22]

Across South-East Asia, where the consumption of raw fish is a common practice, other FBTs also remain a concern.[23,24] In this study, heterophyidiasis was present in 3.3% of samples and up to 26% in one village in Jose Dalman. This is not an unexpected finding, given the similarities in the mode of transmission of heterophyidiasis and capillariasis acquired by consuming

raw or undercooked freshwater fish. Heterophyidiasis is an emerging fish-borne helminthic disease with a reported prevalence of 2.4% in New Corella, Davao del Norte,[25] and up to 36% in Monkayo, Davao de Oro;[26] both municipalities are on the island of Mindanao.

Taeniasis was detected in both Jose Dalman (1.3% of samples) and Pres Manuel A Roxas (2.0% of samples). This is higher than the 0.5% prevalence threshold set by WHO for starting a control programme. The recommended next step to initiate preventive chemotherapy and control taeniasis is to collect data on poor sanitation, the presence of free-roaming pigs and porcine cysticercosis in the community.[27]

In addition to capillariasis and other FBHs, we detected STH in samples from both Jose Dalman and Pres Manuel A Roxas, with prevalence of more than 25% in some villages. However, we could not determine the intensity of infection, as the diagnostic tests used were not able to count the number of eggs per gram of stool. The presence of STH may have led to high rates of malnutrition and poor school performance.[28] The moderate prevalence of STH may be due to low rates of drug administration coverage before the COVID-19 pandemic, as well as low water, sanitation and hygiene (WASH) coverage.[9] Moreover, further disruption of service delivery during the pandemic may have exacerbated the situation.[29]

Schistosomiasis was only seen among study participants from two villages in Jose Dalman, which have not yet been categorized as endemic for schistosomiasis.[30] However, some participants with no history of travel to schistosomiasis-endemic areas tested positive for schistosomiasis, indicating possible transmission within the community. Our calculated prevalences (3.6% in Bitoon and 4.9% in Lumaping) may be underestimated, given that only one aliquot was examined (with approximately 50% sensitivity).[31] Moreover, the intensity of infection was not obtained due to the limitations of the diagnostic procedures used. The prevalence of schistosomiasis was reported to be <1% in Zamboanga del Norte during 2009–2014.[30] Sentinel surveillance using school-aged children may be the recommended next step for describing the status of schistosomiasis in the community and monitoring the status of the control programme.[30] Ensuring an adequate supply of albendazole and praziquantel, along with community-led WASH initiatives, will be key to sustaining effective STH and schistosomiasis control programmes.

Despite the potential for outbreaks, capillariasis is not currently a notifiable disease in the Philippines,[32] and diagnosis relies on passive surveillance. Adoption of active case surveillance has the potential to improve the response to reports of possible outbreaks of capillariasis and other FBHs, and thus rates of early diagnosis and treatment. This study was part of a larger effort to develop a FBH surveillance protocol. The municipalities were selected for the survey based on previous reports of FBHs in the community, and the selection of villages was based on the newly developed selection criteria in the methodology. Inclement weather during the parasitological assessment led to difficulties in accessing the villages, setting up the field laboratory and obtaining samples from patients. This was mitigated by close coordination with the local government units, which provided vehicles capable of travelling through difficult terrain. Asymptomatic cases of capillariasis may have been missed due to the selection criteria used. However, as *C. philippinensis* is both oviparous and larviparous, high worm burden is common among cases. Further studies in areas with similar characteristics to the study sites may be needed to determine the correlation between prevalence of capillariasis and proximity to bodies of freshwater.

Four key strategies for the control of capillariasis and other FBHs are: (i) early diagnosis and treatment; (ii) adequate supply of life-saving medication; (iii) provision of safe WASH; and (iv) culturally sensitive health promotion and education.[10] In the Philippines, capacity development for medical technologists to assist in surveillance, early diagnosis and treatment, as well as training for physicians, nurses, midwives and VHWs in case management, may enable the delivery of enhanced services for diagnosis, treatment, control and prevention of capillariasis and other FBHs. Greater collaboration and stronger partnerships between the Department of Health, local government units and other stakeholders, coupled with appropriate technical support from academia, could also contribute to enhancing prevention and control of these diseases. Moreover, inclusion of capillariasis in the list of notifiable diseases should be considered.

The results of the study were presented to the Department of Health–Zamboanga Peninsula Center for Health Development, the Zamboanga del Norte Provincial Health Office, the Congressional Office of the 2nd District of Zamboanga del Norte, and the local government units in the municipalities of Jose Dalman and Pres Manuel A Roxas.

Conclusion

Capillariasis remains a public health challenge in Jose Dalman and Pres Manuel A Roxas, Zamboanga del Norte, and is co-endemic with other FBH, STH, schistosomiasis and intestinal protozoan infections. The introduction of an active surveillance programme using a predefined set of criteria to identify suspected cases has the potential to improve the detection and diagnosis of capillariasis and other intestinal parasitoses, and could lead to the earlier treatment of cases.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

The study protocol was reviewed and approved by the University of the Philippines Manila Research Ethics Board (UPMREB 2021-0630-01). Informed consent was obtained prior to the collection of stool samples. All submitted stool samples were processed and examined by trained medical technologists from the research team, the Department of Health of the Philippines and partner local government units. Patients who tested positive for intestinal capillariasis or other parasitoses were referred to the respective rural health units for appropriate treatment. Feedback fora were conducted to relay the results and recommendations to concerned stakeholders for appropriate action.

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Hepatitis B testing coverage and positivity rates among pregnant women attending antenatal clinics, Efate Island, Vanuatu, 2018–2020

Rubby Leiwia Dick,[a] Leila Bell,[b,c] George Junior Pakoa,[a] Sereana Natuman Damutalau,[d] Kaylene Kalmos[d] and Caroline van Gemert[b]

Correspondence to Rubby Leiwia Dick (email: dleiwia@vanuatu.gov.vu, leiwiad@gmail.com)

Objective: The World Health Organization has set a target for 95% of pregnant women to be tested for hepatitis B virus at their first antenatal care visit. This study assessed testing coverage and test positivity at the first antenatal care visit among pregnant women between 2018 and 2020 on Efate Island, Shefa province, Vanuatu.

Methods: This cross-sectional study used unlinked first antenatal care consultation and hepatitis B surface antigen testing data, where consultation data were extracted from the Vanuatu Ministry of Health's Health Information Management System and District Health Information System 2, and hepatitis B virus test data were extracted from the Vila Central Hospital Serology Unit registry. Data were restricted to the period of 1 January 2018 to 31 December 2020. Testing coverage and positivity rates were calculated for each year, and Poisson regression models were used to assess changes over time.

Results: First antenatal care visits were reported for each year, with the hospital providing 79.3% (7943/10 020) of consultations. Average hepatitis B virus testing coverage was 89.2% (8942/10 020) over the study period. Of 8942 first antenatal care hepatitis B virus tests performed, 621 (6.9%) were positive. Poisson regression indicated that test coverage and positivity did not change significantly over time.

Discussion: Although hepatitis B virus testing coverage at first antenatal care visits was high, it did not reach the World Health Organization target of 95%, and more recent data suggest a decline since 2020, highlighting the need for ongoing monitoring. A hepatitis B virus positivity rate of 6.9% reflects intermediate endemicity, indicating a substantial risk of mother-to-child transmission. Strengthening such testing and birth-dose vaccination delivery is critical to reducing perinatal transmission in Vanuatu.

Hepatitis B is a viral infection of the liver caused by the hepatitis B virus (HBV), a double-stranded enveloped DNA virus.[1] HBV is primarily transmitted through contact with blood or other body fluids of an infected person, with vertical mother-to-child transmission (MTCT) during birth and horizontal transmission during early childhood being the most common routes of transmission.[2] The global burden of HBV infection is significant, with an estimated 240 million people living with chronic hepatitis B infection in 2024 and 1.2 million new infections occurring each year.[3] In the World Health Organization (WHO) Western Pacific Region, an estimated 102 million people are living with chronic HBV infection.[3]

Antenatal HBV testing through routine antenatal care (ANC) is required to identify HBV-infected pregnant women for further management to prevent MTCT, including antiviral prophylaxis during pregnancy.[2] WHO has set regional targets in Asia and the Pacific to test more than 95% of pregnant women for HBV, alongside HIV and syphilis (the triple elimination targets), recommending that testing occurs during the first antenatal care (ANC-1) visit.[4] HBV testing is conducted through testing for the

[a] Vila Central Hospital Laboratory, Port Vila, Vanuatu.
[b] Burnet Institute, Melbourne, Victoria, Australia.
[c] Monash University, Melbourne, Victoria, Australia.
[d] Ministry of Health, Port Vila, Vanuatu.
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hepatitis B surface antigen (HBsAg). A recent systematic review of coverage and progress towards the triple elimination targets, including hepatitis B, found that coverage-related data were limited across the Pacific and, where available, indicated that most countries were not on track to meet elimination targets, including ANC-1 HBV testing targets.[5]

The prevalence of chronic HBV infection, defined as testing positive for HBsAg for more than 6 months, in the Pacific island nation of Vanuatu is high, with an estimated 9% (approximately 27 000 people) of the population living with chronic HBV infection.[5] The population of Vanuatu was estimated to be 300 019 in 2020, with approximately 49 034 people (16%) living in the capital, Port Vila, located on Efate Island, Shefa province.[6] Vanuatu is classified as a low-middle-income country by the World Bank, with a gross domestic product per capita of US$ 3959.90 in 2025.[7] Laboratory testing is centralized, with rapid diagnostic tests (Abbott Determine HBsAg 2, a lateral flow immunochromatographic test) used primarily in hospital-based laboratories and additional tests, such as viral load and liver function tests, available only at Vila Central Hospital (VCH; officially renamed Vanuatu National Hospital) (Tassiets A, personal communication, 20 December 2025).

In April 2022, the Vanuatu Ministry of Health (MOH) implemented partial decentralization of ANC services, moving them from hospitals to community-based clinics, while laboratory services remained centralized.[8] Prior to decentralization, ANC-1 HBV testing coverage in Vanuatu was unknown. This study aimed to calculate ANC-1 HBV testing coverage and positivity on Efate Island between 2018 and 2020 to inform programmatic strategies for reducing HBV transmission and MTCT.

METHODS

Study design and setting

A retrospective cross-sectional study was conducted using routinely collected, aggregated ANC-1 data from Efate Island, Shefa province, between 2018 and 2020. ANC services were provided at VCH (centralized), three government-run community clinics (Paunagisu, Erakor and Imere) and one government-affiliated clinic (Vanuatu Family Health Association [VFHA], Port Vila). Government ANC services charged 300 vatu (~US$ 2.48) per ANC-1 visit, while ANC HBV testing was free; VFHA charged 500 vatu for consultation and 300 vatu for testing. Private clinics were excluded.

Study population

All pregnant women attending for ANC-1 at participating facilities or presenting for ANC-1 HBV testing at VCH between 1 January 2018 and 31 December 2020 were included in the study. Records were restricted to women aged 10–50 years. Most were assumed to be Indigenous Vanuatu people. Due to incomplete data, it was not possible to include more recent data in the analysis.

Data collection

Individual-level records (paper-based or electronic) are not collected in any of the government-run health services in Vanuatu. Aggregated data on the total number of ANC-1 visits on Efate Island were extracted from the Health Information Management System used by the Vanuatu MOH and District Health Information System 2 (DHIS2, University of Oslo, Norway) for the period from 1 January 2018 to 31 December 2020. DHIS2 is a free, open-source software platform for collecting, managing, analysing and sharing data. It is used in Vanuatu for the monthly collation of data about health facility-level engagement, and includes aggregated data on the number of health facility interactions and some limited information on health outcomes. Data collected in monthly reports that were used in this study include the total number of ANC-1 visits per month per facility. Data were cross-checked with paper-based logbooks at each health facility to confirm accuracy. Individual-level ANC-1 HBV testing data were extracted from the VCH serology unit registry for all tests conducted among patients whose reason for testing was recorded as ANC-1. Data extracted included patient date of birth, test date and test result; information about the referring ANC-1 clinic was not collected. Duplicate records (based on name, date of birth and test date) were removed from the analysis.

Data analysis

Outcome measures included the ANC-1 HBV testing rate (calculated as the total number of ANC-1 HBV tests divided by the total number of ANC-1 consultations, by year, expressed as a percentage) and the ANC-1 HBV test positivity rate (defined as the total number of ANC-1 HBV

Table 1. **Number of annual ANC-1 consultations and ANC-1 HBV tests and corresponding testing and positivity rates, Vanuatu, 2018–2020**

	2018	2019	2020	Total	*P* (trend)
No. of ANC-1 consultations	3289	3354	3377	10 020	NA
No. (%) of ANC-1 consultations by service provider					
Vila Central Hospital	2709 (82.4)	2671 (79.6)	2563 (75.9)	7943 (79.3)	NA
Vanuatu Family Health Association	341 (10.4)	453 (13.5)	494 (14.6)	1288 (12.9)	NA
Other	239 (7.3)	230 (6.9)	320 (9.5)	789 (7.9)	NA
No. (%) of HBV tests at ANC-1	2897 (88.1)	3036 (90.5)	3009 (89.1)	8942 (89.2)	0.12
No. (%) of positive HBV tests at ANC-1	205 (7.1)	208 (6.9)	208 (6.9)	621 (6.9)	0.98

ANC-1: first antenatal care visit; HBV: hepatitis B virus; NA: not applicable.

positive test results during a defined time period, divided by the total number of ANC-1 HBV tests with a known result, by year, expressed as a percentage). Poisson regression with robust standard errors was used to assess changes in ANC-1 HBV test coverage and test positivity by year, including the number of ANC-1 consultations and the number of ANC-1 HBV tests conducted, respectively, as offsets. Measures were calculated by year, over the total study period and by health facility type (government-run or government-affiliated). Data were cleaned and managed in Microsoft Excel, and statistical analyses were conducted using Stata (version SE 18, StataCorp, College Station, Texas, United States of America).

RESULTS

A total of 10 020 ANC-1 visits were recorded at participating clinics between 1 January 2018 and 31 December 2020 (**Table 1**). The annual number of ANC-1 consultations remained stable, ranging from 3289 in 2018 to 3377 in 2020, with an average of 3340 per year. Among all ANC-1 visits, the majority (n = 7943, 79.3%) were conducted at the VCH ANC clinic. The largest volume of community-based ANC-1 services was provided by VFHA, accounting for 12.9% (n = 1288) of all ANC-1 consultations, and the smaller community-based health facilities provided the remainder of ANC-1 consultations (n = 789, 7.9%).

A total of 8942 ANC-1 HBV tests were performed between 2018 and 2020, with an average of 2980 tests each year. The median age of women receiving an HBV test as part of ANC-1 was 27.3 years (standard deviation 5.9, range 12–50 years; data not shown).

ANC-1 HBV test coverage was high and stable over time, at 88.1% (2897/3289) in 2018, 90.5% (3036/3354) in 2019, and 89.1% (3009/3377) in 2020. In Poisson regression models accounting for the number of ANC-1 consultations, there was no evidence that HBV test coverage differed by year ($P \geq 0.05$).

Among the total 8942 ANC-1 HBV tests performed during the reporting period, 621 were positive (6.9%). Test positivity decreased slightly from 7.1% (205/3289) in 2018 to 6.9% in both 2019 (208/3036) and 2020 (208/3009); however, the decrease was not statistically significant ($P \geq 0.05$).

DISCUSSION

The study found that just less than 90% of pregnant women on Efate Island attending an ANC clinic had an HBV test at their ANC-1 consultation between 2018 and 2020. While below the 95% WHO target, this is high coverage, particularly when considering the challenges associated with accessing health-care services in Vanuatu. A large proportion of pregnant women accessed ANC-1 services at VCH, with less than one third accessing ANC-1 services from community-based health centres, which likely contributed to the high testing rate due to co-location and convenience of the laboratory testing facilities at VCH.

In April 2022, the Vanuatu MOH implemented a partial decentralization policy, whereby ANC services were expanded from hospital-based to community-based health clinics, while laboratory services remained

centralized.[8] Data were not available to calculate the ANC-1 HBV testing rates and test positivity rates for 2021 and 2022; however, unpublished data from VCH suggest that ANC-1 HBV test numbers decreased considerably in 2021, from 3009 tests in 2020 to 971 in 2021 (a reduction of 67.7%). The observed reduction in testing may reflect financial and logistical barriers, such as the cost and complexity of travelling to laboratory services for testing, in addition to difficulties accessing community-based ANC, highlighting the importance of expanding ANC-1 HBV testing through effective implementation of decentralization strategies in primary- and community-care settings.[9,10] Disruptions related to the COVID-19 pandemic are also likely to have contributed: Vanuatu experienced community transmission for the first time in March 2022.[11,12] Ongoing monitoring of ANC-1 HBV testing coverage is, therefore, recommended to support programmatic oversight and enable timely identification and response to declines in testing uptake.

The high ANC-1 testing rate reported in this study is unlikely to be reflective of ANC-1 HBV testing rates in rural and remote areas of Vanuatu. The country's population is widely distributed, living across 65 inhabited islands and served by two referral hospitals, four provincial hospitals and 34 health centres,[13] and with a Universal Health Coverage Index of 52 in 2023.[14] In highly geographically isolated settings such as Vanuatu, decentralized ANC-1 HBV testing is crucial. Nurse- and midwife-administered HBV ANC testing was piloted in Vanuatu as part of a field trial in selected sites to prevent MTCT of hepatitis B in 2024,[5] with early results suggesting feasibility and acceptability;[15] however, further deliberation is needed to ensure sustainable resourcing and feasibility in remote areas. Expanded monitoring of ANC-1 and ANC-1 HBV test coverage is recommended to ensure that differences related to location and service type can be identified and addressed. Additionally, differences in access to and use of ANC-1 and ANC-1 HBV testing by other factors such as age, education and gravidity should be considered and monitored, where possible, to ensure equitable access for all pregnant women.

HBV positivity among ANC-1 women was 6.9%, consistent with intermediate endemicity according to classifications used by WHO and others.[16] Although below the high-prevalence threshold (≥8%), this level indicates a substantial risk of MTCT and underscores the importance of routine antenatal screening to facilitate access to follow-up care for subsequent clinical management, such as peripartum antiviral prophylaxis where feasible, and timely hepatitis B vaccine within 24 hours of birth. Of concern is the fact that hepatitis B birth dose coverage was estimated at only 59% in Vanuatu in 2020,[17] leaving a considerable proportion of infants unprotected and at risk of perinatal infection. Providing peripartum antiviral prophylaxis where feasible, in addition to increasing birth-dose vaccination and follow-up among exposed infants, is therefore critical to reduce vertical transmission in this population.

There are some limitations to this study that should be considered. First, this is a cross-sectional descriptive study, where data linkage across sites and years was not possible. There may be some bias in the data. Due to the absence of unique patient identifiers, it is possible that there was misclassification or duplication in laboratory records, and we are unable to account for demographic or behavioural confounders. As noted, the data included are only from health facilities on Efate Island, and findings are thus not representative across Vanuatu. Second, the data do not include private health facilities; however, anecdotal evidence suggests the number of women accessing private ANC-1 is low. Third, while the Abbott Determine HBsAg 2 test is considered to have acceptable sensitivity and specificity, there may be variations in test performance or testing procedures, or contextual factors that impacted prevalence estimates.

Conclusion

ANC-1 HBV testing coverage on Efate Island was high but below the WHO target, and positivity remains at intermediate endemic levels, indicating ongoing MTCT risk. Strengthened decentralized testing, birth-dose vaccination and follow-up for exposed infants are essential to reduce perinatal HBV transmission in Vanuatu. Ongoing monitoring of ANC-1 and ANC-1 HBV test coverage, disaggregated by province and service type, is also essential to monitor coverage of essential interventions during the decentralization process.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

As this study used routinely collected and de-identified data, it did not require ethics approval. However, the Vanuatu MOH Human Research Ethics Committee provided ethical approval for this study.

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Evaluation of the Cambodia Field Epidemiology Training Program, 2019–2024: public health response and stakeholder perspectives

Sokly Mom,[a,b,c] Natthaprang Nittayasoot[c] and Sengdoeourn Yi[a,b]

Correspondence to Sokly Mom (email: sokly.moh@gmail.com)

Objective: Field epidemiology training programmes (FETPs) are designed to develop a competent public health workforce to effectively detect and respond to diseases. In Cambodia, five FETP cohorts had graduated by 2024, yet no formal evaluation had taken place. This study aimed to describe the characteristics of these FETP graduates, assess their involvement in public health responses, and explore the perspectives of stakeholders and graduates.

Methods: A mixed-methods cross-sectional study was conducted among Cambodia's FETP–Frontline and FETP–Intermediate graduates and key informants. Participants consisted of 81 graduates from five cohorts (2019–2024) and four leaders from the Ministry of Health and provincial health departments. Quantitative data were collected using a structured online questionnaire, and qualitative data through key informant interviews. Descriptive statistics summarized quantitative findings, while thematic analysis was applied to qualitative data.

Results: Of the graduates surveyed, most were Frontline level (80.2%, 65/81) and male (64.2%, 52/81). The median age was 34 years; 60.5% (49/81) had a bachelor's degree. Overall, 79.0% (64/81) reported participating in public health responses and 65.4% (53/81) in surveillance evaluations. The key informants attested to graduates' continued active involvement in public health responses.

Discussion: Cambodia's FETP appears to have strengthened the public health workforce, with most graduates contributing to outbreak response and surveillance. However, the number of FETP–Intermediate graduates was small, and their limited use of epidemiological skills highlighted the need for expanded training and improved skill development. Stakeholders emphasized the programme's importance but noted that sustainability requires stronger domestic investment and funding. Overall, the FETP has enhanced epidemiological capacity, yet greater customization, domestic investment and expanded training are essential for long-term impact.

Field epidemiology training programmes (FETPs) are designed to strengthen the capacity of the public health workforce to detect, investigate and respond to health threats in alignment with the International Health Regulations (IHR, 2005).[1–3] FETP core competencies include surveillance, outbreak investigation, data analysis, scientific communication, leadership and the ability to use epidemiological tools.[4] The programme is structured into three tiers – Frontline, Intermediate and Advanced – each tailored to specific levels of responsibility and skill.[1,4] Globally, FETPs operate in more than 150 countries and areas,[5] with more than 22 000 FETP alumni contributing to surveillance and responses to outbreaks or other health events.[6] Evaluations of FETPs across countries have demonstrated their critical role in strengthening health systems. Studies from Jordan, Yemen and the World Health Organization's (WHO) Eastern Mediterranean and Western Pacific Regions have demonstrated that FETP graduates play critical roles in emergency responses, improving surveillance system performance, and supporting evidence-based decision-making within ministries of health.[7–9] These findings underscore the importance of sustained financial support, expansion of programmes to countries without FETPs, adoption of preparatory self-paced online courses, and institutionalization to ensure long-term sustainability and national ownership.[7–10]

[a] Department of Communicable Disease Control, Ministry of Health, Phnom Penh, Cambodia.
[b] Cambodia Field Epidemiology Training Program, Department of Communicable Disease Control, Ministry of Health, Phnom Penh, Cambodia.
[c] International Field Epidemiology Training Program, Ministry of Public Health, Nonthaburi, Thailand.
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In 1951, the United States Centers for Disease Control and Prevention (US CDC) established the Epidemic Intelligence Service, an in-service training programme that later became the foundational model for FETPs. From 1980 onward, the US CDC partnered with countries to support the development of national FETPs.[1] Cambodia's Department of Communicable Disease Control (CCDC) established a nationwide network of rapid response teams (RRTs) to enhance capacities for surveillance and outbreak response.[11] With technical and financial assistance from WHO and the US CDC, the CCDC launched the Applied Epidemiology Training (AET) programme in 2011.[12] The AET comprised two components: a 6-week introductory course on surveillance principles and outbreak investigation, and a 6-month foundation course emphasizing surveillance, field investigation, epidemiological methods and scientific communication.

In 2019, the AET evolved into an FETP, comprising two levels: FETP–Frontline and FETP–Intermediate. Both focus on four key domains: public health surveillance, field investigation, epidemiological methods and scientific communication. The Frontline curriculum emphasizes essential skills such as summarizing surveillance data, monitoring reporting systems, interpreting findings and preparing timely reports. The Intermediate curriculum builds upon these competencies, training participants to evaluate surveillance systems, investigate outbreaks, design and analyse studies, and produce evidence-based reports for policy and programme decision-making.

A total of 139 individuals completed the AET in 2011–2018, and by the end of 2024, 96 had completed the FETP, comprising 76 Frontline and 20 Intermediate graduates in five cohorts (there was no cohort in 2021 due to the COVID-19 pandemic). Participants were Ministry of Health (MOH) staff working at all levels, serving as RRT members or public health officers directly involved in surveillance and outbreak response. Despite 5 years of FETP implementation, Cambodia's FETP had not yet been evaluated. This evaluation aimed to generate evidence and insight into the Cambodia FETP by describing its graduates' characteristics and contributions to public health responses in Cambodia.

METHODS

Study design and setting

This mixed-methods study used an explanatory, sequential, cross-sectional design to collect data from October 2024 to January 2025. An online questionnaire was used to quantitatively evaluate FETP graduates' involvement in public health responses. Qualitative data were collected through interviews with key informants to explore the perspectives of programme representatives and Provincial Health Department policy-makers who sent their officers to attend the FETP. The Kirkpatrick model was applied to assess the impact of the FETP.[12] This model has been widely used for training evaluations, including in FETP assessments globally.[9,13–16] In this study, Level 3 (behaviour) was assessed by examining how FETP graduates applied their acquired skills in the workplace, while Level 4 (results) evaluated the benefits of the training to the organization and its impacts on the health system by collecting stakeholder feedback on programme outcomes and alumni contributions.

Sampling strategy

The FETP maintains a database of the 96 individuals who graduated between January 2019 and December 2024, along with contact information for stakeholders, including management at the national and provincial levels who sent their staff to attend the FETP. For the quantitative study, all 96 FETP graduates were invited to participate in the online questionnaire using the census sampling approach. For the qualitative study, purposive sampling was used to select key informants, including senior MOH policy-makers overseeing the FETP and representatives from provincial health departments that had nominated staff to the programme. Four stakeholders were interviewed: one national-level policy-maker responsible for the FETP, one provincial RRT manager and two deputy directors of provincial health departments.

Questionnaire development and validation

The questionnaire was developed based on the core competencies of the FETP and was adapted from

a previous questionnaire used to evaluate the AET programme in Cambodia in 2019 (Ministry of Health, unpublished data, 2020). To ensure clarity and accuracy, the researchers piloted the questionnaire among AET alumni and revised it based on their feedback. In addition, the questionnaire was shared with Cambodian senior epidemiologists and FETP mentors, who reviewed the validity of the questionnaire's content to ensure its relevance and alignment with public health response activities and evaluation needs.

Data collection

The online questionnaire was administered using Google Forms. The survey URL was shared via the Telegram group for FETP graduates in Cambodia. All participants received a brief explanation of the study, the questionnaire and study objectives before starting the survey. The first of the survey's three sections covered demographics (age, sex, education, current position and employer). The second was a self-assessment that used structured questions to evaluate key public health activities engaged in after graduation, with a question included to capture the types of public health events (e.g. the COVID-19 pandemic, dengue outbreaks and foodborne disease outbreaks). Participants then assessed their engagement in public health activities using a 4-point frequency scale (from 1 = never to 4 = often) across 20 field epidemiology tasks. In the third section, participants were asked to rate their perceptions of training effectiveness using Likert-type scales (from not effective to very effective; no change to much better; and poor to excellent). Participants were also asked whether they agreed or disagreed with a series of statements about the programme, to identify its strengths and weaknesses.

Qualitative data were collected through face-to-face interviews with stakeholders using a semi-structured interview guide, with topics including the stakeholders' perspectives on the programme, its impact on public health responses and considerations about the programme's sustainability, and human resources and financial commitments. Interviews were audio-recorded using a mobile phone application and supplemented with written notes for transcription.

Data analysis

Quantitative data were analysed using STATA version 14 (StataCorp, College Station, TX, USA) and Microsoft Excel version 16.1 (Redmond, WA, USA). Categorical variables were summarized using frequencies and percentages. Continuous variables were reported as median and interquartile range (Q1–Q3). Qualitative data were extracted from recordings and written notes, transcribed, and then coded within Excel spreadsheets. A thematic analysis was conducted after categorizing the information into cross-cutting themes, which were defined based on the content of the interviews.

RESULTS

Characteristics of FETP participants

Of the 96 FETP graduates, 81 (84.4%) completed the questionnaire. Of these respondents, 65 (80.2%) were FETP–Frontline graduates, and 16 (19.8%) were FETP–Intermediate graduates. The median age was 34 years (interquartile range: 31–37 years), and 52 (64.2%) were male. Most held a bachelor's degree (49, 60.5%) at the time of the survey. The most common professional backgrounds were nursing (35, 43.2%), medicine (13, 16.0%) and midwifery (11, 13.6%). Graduates were most frequently employed at the operational district level (36, 44.4%) or provincial health department level (26, 32.1%) (**Table 1**). The graduates were deployed across most provinces, with higher concentrations observed in the central and southern regions. However, no FETP graduates from two provinces – Pailin and Koh Kong – responded to the survey. Fourteen of 25 provinces (56.0%) had at least one Intermediate respondent **Fig. 1**.

Public health involvement

Overall, 64 (79.0%) respondents reported involvement in public health responses: 49 (75.4%) Frontline and 15 (93.8%) Intermediate graduates. Surveillance evaluation activities were reported by 53 (65.4%) graduates: 40 (61.5%) Frontline and 13 (81.3%) Intermediate. Research activities were less common, with 33 (40.7%) graduates reporting involvement: 23 (35.4%) Frontline and 10 (62.5%) Intermediate (**Table 1**).

Most graduates (63/81, 77.8%) took part in responses to COVID-19, and many took part in responses to foodborne illnesses (35/81, 43.2%), influenza (29/81, 35.8%) and dengue (29/81, 35.8%), with a higher proportion of Intermediate graduates engaged in responses compared with Frontline graduates (**Fig. 2**). **Table 2**

Table 1. **Demographic characteristics and participation in public health activities, by type of FETP graduate, Cambodia, 2019–2024**

Characteristic	Total (*N* = 81)	Frontline (*n* = 65)	Intermediate (*n* = 16)
Age group, years			
24–33	35 (43.2)	25 (38.5)	10 (62.5)
34–44	43 (53.1)	38 (58.5)	5 (31.3)
≥45	3 (3.7)	2 (3.1)	1 (6.3)
Median (interquartile range, Q1–Q3) age, years	34 (31–37)		
Sex			
Male	52 (64.2)	41 (63.1)	11 (68.8)
Female	29 (35.8)	24 (36.9)	5 (31.3)
FETP graduates by cohort year[a]			
2019	18 (22.2)	18 (27.7)	0 (0)
2020	15 (18.5)	15 (23.1)	0 (0)
2021	0 (0)	0 (0)	0 (0)
2022	29 (35.8)	29 (44.6)	0 (0)
2023	16 (19.8)	7 (10.8)	9 (56.3)
2024	19 (23.5)	12 (18.5)	7 (43.8)
Highest educational background			
Associate's degree	18 (22.2)	14 (21.5)	4 (25.0)
Bachelor's degree	49 (60.5)	41 (63.1)	8 (50.0)
Master's degree	14 (17.3)	10 (15.4)	4 (25.0)
Professional background			
Nursing	35 (43.2)	29 (44.6)	6 (37.5)
Doctor of medicine	13 (16.0)	11 (16.9)	2 (12.5)
Midwifery	11 (13.6)	9 (13.8)	2 (12.5)
Medical laboratory	7 (8.6)	4 (6.2)	3 (18.8)
Public health or epidemiology	5 (6.2)	2 (3.1)	3 (18.8)
Pharmacy	4 (4.9)	4 (6.2)	0 (0)
Medical or dental	3 (3.7)	3 (4.6)	0 (0)
Information technology	3 (3.7)	3 (4.6)	0 (0)
Current position			
Health officer	38 (46.9)	31 (47.7)	7 (43.8)
Head or deputy of unit	22 (27.2)	18 (27.7)	4 (25.0)
Programme or deputy manager	5 (6.2)	3 (4.6)	4 (25.0)
Administrative officer	5 (6.2)	5 (7.7)	0 (0)
Chief or vice chief of office	4 (4.9)	4 (6.2)	0 (0)
Laboratory manager	3 (3.7)	3 (4.6)	0 (0)
Physician or health consultant	2 (2.5)	1 (1.5)	1 (6.3)
Median (Q1–Q3) years in current position	5 (2–8)		

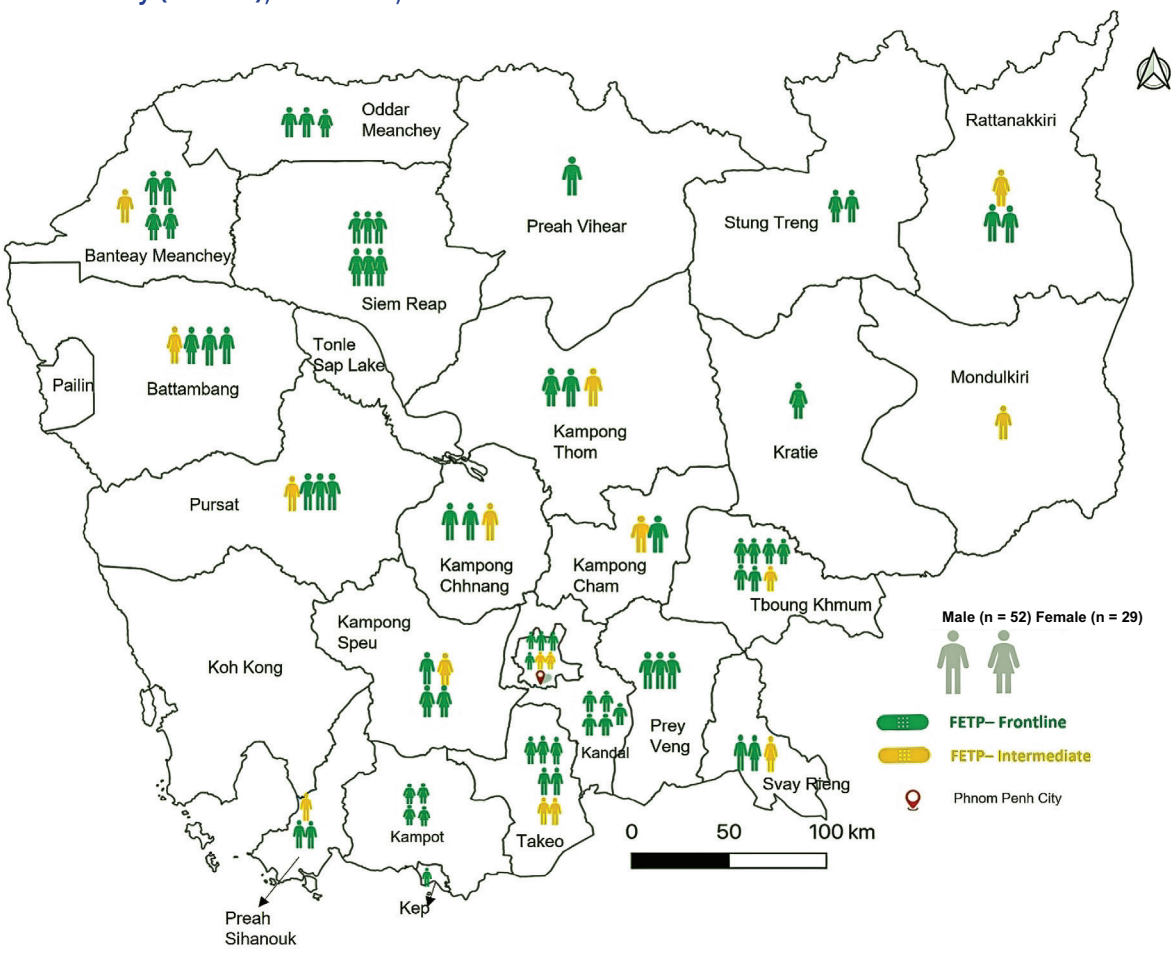
Characteristic	Total (*N* = 81)	Frontline (*n* = 65)	Intermediate (*n* = 16)
Employer			
National level (Ministry of Health)	5 (6.2)	4 (6.2)	1 (6.3)
Provincial health department level	26 (32.1)	19 (29.2)	7 (43.8)
Operational district level	36 (44.4)	29 (44.6)	7 (43.8)
Referral hospital level	9 (11.1)	9 (13.8)	0 (0)
Health centre level	3 (3.7)	3 (4.6)	0 (0)
Other (nongovernmental and non-health-related government sectors)	2 (2.4)	1 (1.5)	1 (6.3)
Median (Q1–Q3) years of experience in health sector	10 (7–12)		
Type of public health activity			
Public health response (disease outbreak, public health emergency)	64 (79.0)	49 (75.4)	15 (93.8)
Surveillance evaluation (data quality audit, surveillance evaluation)	53 (65.4)	40 (61.5)	13 (81.3)
Research studies (survey, assessment)	33 (40.7)	23 (35.4)	10 (62.5)

FETP: field epidemiology training programme; Q1: first quartile; Q3: third quartile.

Values are *n* (%) unless otherwise indicated.

[a] FETP–Intermediate cohorts are selected from previous cohorts of FETP–Frontline graduates.

Fig. 1. **Geographical distribution of FETP–Frontline and FETP–Intermediate graduates who responded to the survey (*N* = 81), Cambodia, 2024–2025[a]**



FETP: field epidemiology training programme.

[a] The data reflect graduate placements by province as part of efforts to strengthen the national public health workforce.

Table 2. **Involvement of FETP–Frontline and FETP–Intermediate graduates (N = 81) in public health activities, Cambodia, 2019–2024**

Categorical variables	No. (%) involved			
	Often	Sometimes	Rarely	Never
Training for public health professionals	9 (11.1)	20 (24.7)	15 (18.5)	37 (45.7)
Mentorship for public health professionals	8 (9.8)	22 (27.2)	14 (17.3)	37 (45.7)
Surveillance evaluations	20 (24.7)	27 (33.3)	16 (19.8)	18 (22.2)
Data quality audits	13 (16.0)	32 (39.5)	19 (23.5)	17 (21.0)
Surveillance data analysis and reporting	16 (19.8)	33 (40.7)	15 (18.5)	17 (21.0)
Case investigations	14 (17.3)	39 (48.2)	16 (19.7)	12 (14.8)
Outbreak investigations	18 (22.2)	37 (45.7)	14 (17.3)	12 (14.8)
Collection, handling and transport of specimens	9 (11.1)	32 (39.5)	23 (28.4)	17 (21.0)
Use of computer software (e.g. Microsoft Excel, PowerPoint, Word)	50 (61.7)	17 (21.0)	5 (6.2)	9 (11.1)
Staff and resource management	9 (11.1)	31 (38.3)	15 (18.5)	26 (32.1)
Descriptive statistical analysis	9 (11.1)	24 (29.6)	22 (27.2)	26 (32.1)
Inferential statistical analysis	2 (2.5)	14 (17.3)	27 (33.3)	38 (46.9)
Public health research	7 (8.6)	31 (38.3)	13 (16.1)	30 (37.0)
Health policy, strategy or guideline development	5 (6.2)	23 (28.4)	23 (28.4)	30 (37.0)
Scientific reports and presentations for conferences	5 (6.2)	24 (29.6)	18 (22.2)	34 (42.0)
Publications	1 (1.2)	13 (16.0)	19 (23.5)	48 (59.3)

shows that FETP graduates at both levels were frequently involved in public health activities, with 18 (22.2%) often involved in conducting outbreak investigations, but only 5 (6.2%) often involved in developing health policies, strategies or guidelines. Self-reported participation by FETP level is shown in **Supplementary Fig. 1**.

Perspectives of graduates towards the FETP

Graduates reported a positive perception of the FETP, with most rating the training as effective or very effective, agreeing that it had improved their work performance and rating the quality of training as good overall (**Supplementary Fig. 2**).

Strengths and weaknesses of the FETP

The key strengths identified by the graduates were in disease surveillance (Frontline 84.6% vs Intermediate 100%), outbreak investigations (Frontline 89.2% vs Intermediate 93.7%) and endemic infection control and emergency response (Frontline 89.2% vs Intermediate 100%). The most frequently identified weaknesses were creating public health leaders (Frontline 41.5% vs Intermediate 68.7%), encouraging cross-agency collaboration (Frontline 33.8% vs Intermediate 37.5%) and creating a basic understanding of public health among members of the medical profession (Frontline 29.2% vs Intermediate 43.7%). Only 29.2% (19/65) of Frontline and 25.0% (4/16) of Intermediate graduates viewed publication as a programme strength (**Fig. 3**).

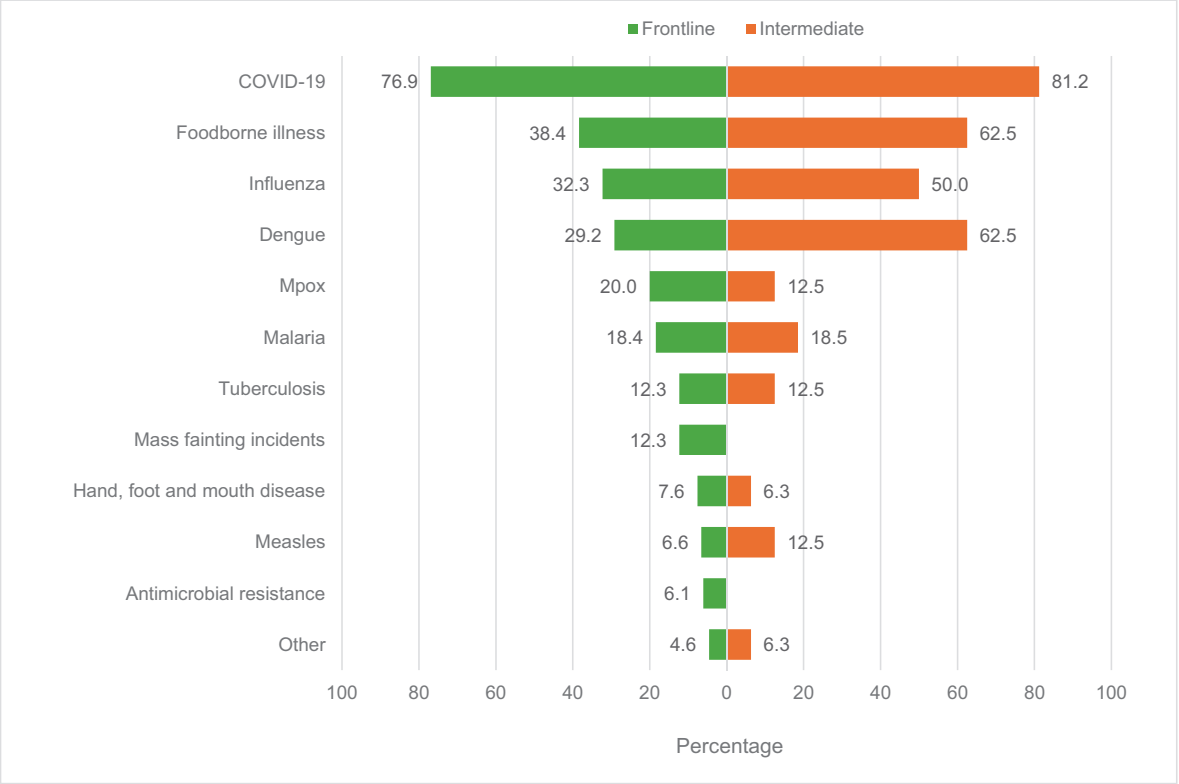
Stakeholders' perspectives of the FETP

The four interviewed stakeholders reported that Cambodia's FETP has strengthened public health responses by improving surveillance and outbreak responses, building capacity and skills, developing the workforce, contributing to professional growth, and improving networking and collaboration. Thematic analysis identified two main cross-cutting themes: 1) the programme's impact on public health responses and 2) concerns about the programme's sustainability and resource commitments (i.e. stable funding from the government).

Impact on responses to public health events

Stakeholders described FETP graduates as essential contributors to surveillance and outbreak investigations across all levels of the health system. During the COVID-19 pandemic and influenza A(H5N1) outbreaks, FETP

Fig. 2. **Distribution of FETP–Frontline (*n* = 65) and FETP–Intermediate (*n* = 16) graduates' self-reported participation in responses to public health events (%), Cambodia, 2019–2024**



FETP: field epidemiology training programme.

graduates were regarded as vital personnel. One FETP management representative noted, "FETP graduates were integral in investigations and response activities at both national and subnational levels." One management representative from a provincial health department stated, "FETP graduates have significantly improved our outbreak response and surveillance capacity."

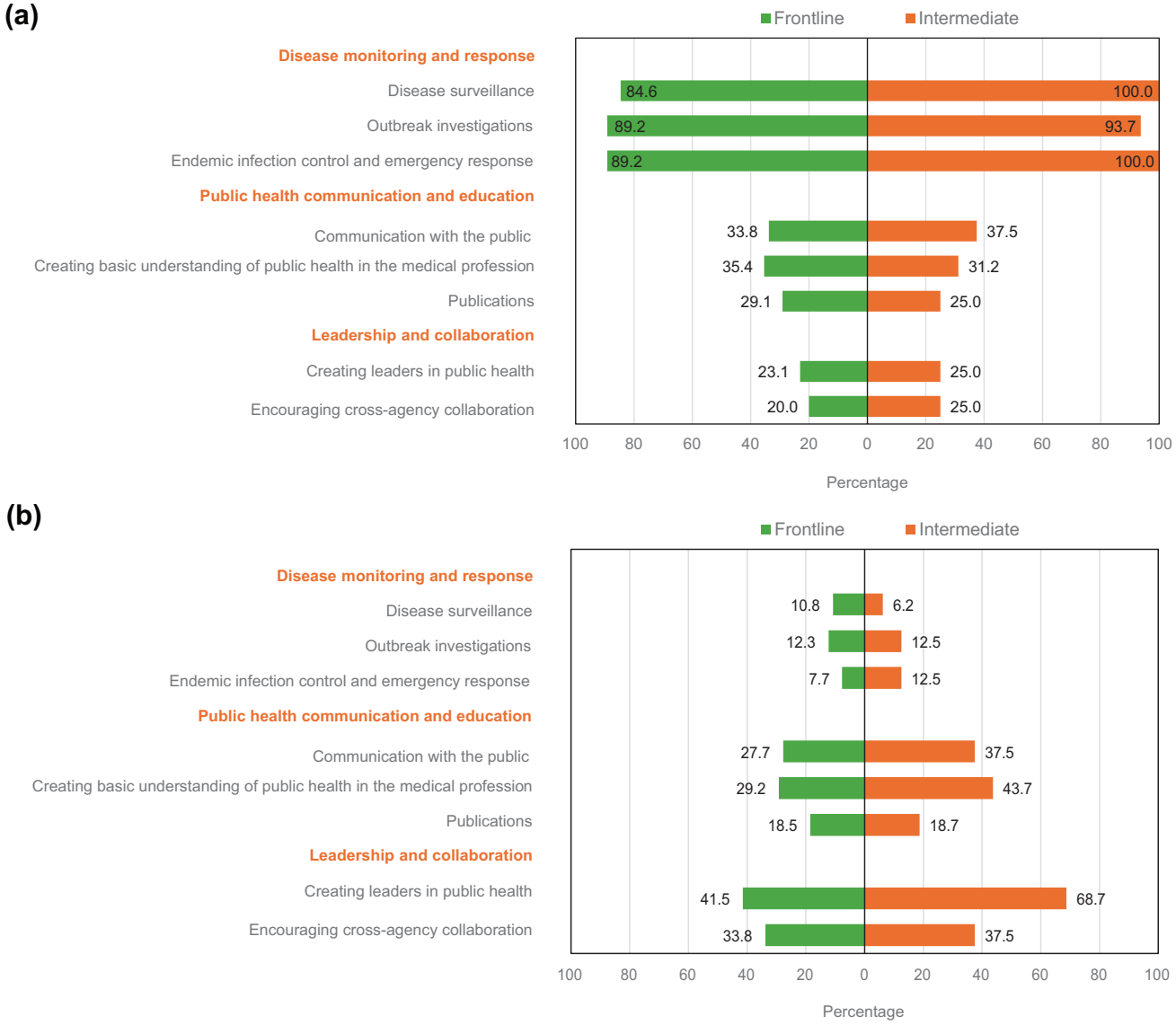
Programme sustainability and resource commitment

Stakeholders highlighted that resource constraints were a significant challenge to sustaining the FETP; they also highlighted the importance of the MOH's plan to co-fund the FETP by 2026 as a step towards reducing dependence on international partners. One FETP management representative stated, "Co-funding and collaboration will be crucial for ensuring that staff at all levels can be trained and equipped to respond to public health threats." An FETP management representative explained, "There is a clear commitment to ensuring the programme's financial sustainability, with a phased transition toward national funding supported by both domestic and international partners." The strategy includes securing co-funding to support training for provincial-level staff and aims to gradually expand the programme's reach while ensuring long-term viability.

DISCUSSION

This evaluation provides evidence of the contribution of FETP graduates to public health responses in Cambodia, highlighting their level of engagement in core public health functions after graduation, and exploring their perceptions of the programme's strengths, weaknesses and overall effectiveness. The findings demonstrate that FETP graduates have been involved in public health activities across all levels of the health system, aligning with the programme's primary objective of enhancing national epidemiological capacity. Most respondents were Frontline graduates, reflecting the larger number of graduates from that programme (*n* = 96), of whom 20 had also completed the Intermediate programme and had been deployed at the district and provincial levels, which demonstrates the effective integration

Fig. 3. **Perceived (a) strengths and (b) weaknesses of the FETP (% who agreed with statements) among Frontline (n = 65) and Intermediate (n = 16) graduates, Cambodia, 2019–2024**



FETP: field epidemiology training programme.

of the FETP within Cambodia's decentralized health system and its role in training primary responders for community disease outbreaks. FETP graduates were shown to be frequently responsible for surveillance and outbreak response in their provinces.

The capacities of FETP graduates enable them to conduct timely and effective responses, reducing the need to rely on national response teams. Notably, no respondents were from Pailin and Koh Kong provinces, suggesting potential geographical gaps in programme reach or follow-up engagement that need addressing. At the time of the survey, about half of all FETP graduates held positions at the supervisor level or higher, despite the lack of a directive aimed at promoting FETP fellows after graduation. Further investigation using comparative methods would be needed to assess whether FETP participation is associated with career advancement. The study's findings are consistent with the qualitative evidence from supervisors at the national and subnational levels: FETP graduates were more knowledgeable about responding to public health threats in their provinces, and they were promoted based on their performance. Other studies indicated that FETP graduates had a more favourable career path after graduation.[13,14,17] This suggests that the training

acquired through the FETP enhances epidemiological skills, leading to improved decision-making and leadership capabilities in addressing public health challenges.[18]

The institutionalization and sustainability of FETPs within national health frameworks are crucial for leveraging these enhanced capacities to meet national health priorities and ensure ongoing public health emergency preparedness.[19] However, the absence of dedicated career progression pathways after graduation can lead to underutilization of these advanced epidemiological skills, posing a challenge for ministries of health, despite the growing evidence that FETPs contribute to surveillance and response capacity.[20] This gap underscores the necessity for formal guidance about recognizing and incentivizing FETP graduates, thereby maximizing their contributions to national health security.[17]

Overall, 79.0% of FETP graduates reported involvement in outbreak response and 65.4% in surveillance activities. This indicates that many graduates used their new skills at the workplace. FETP graduates were active in responding to public health events, including the COVID-19 pandemic, dengue, zoonoses and foodborne illnesses, by staffing emergency operations centres and leading outbreak responses.[21] Other studies have demonstrated that FETPs played a significant role in the global preparedness response to the COVID-19 pandemic.[21,22] Feedback from trainees and implementers indicated that FETP–Frontline graduates have contributed to improvements in surveillance systems, outbreak detection, timely responses, reporting and staff engagement.[15,23] Intermediate graduates consistently demonstrated participation across all public health domains. This aligns with global findings indicating that FETP–Intermediate graduates contribute to field investigations and surveillance evaluations based on the course competencies.[16,24]

Despite strong participation in outbreak response and surveillance, FETP graduates had limited engagement with core epidemiological analysis and dissemination activities, with fewer than 10% frequently presenting at meetings or conferences or publishing their findings. Skills in inferential and descriptive statistical analysis were also reported to be used infrequently (**Table 2**). The results also emphasize the importance of strengthening the FETP curriculum to include leadership and communication, data analysis, research and scientific publication, as well as expanding opportunities for higher levels of FETP training (e.g. through an advanced programme) and offering specific courses for those who require it, including in skills such as epidemiological methods, data analysis and scientific writing. The findings also suggest a need for continuous curriculum improvement to further strengthen the core competencies and technical knowledge of trainees.

Stakeholders highlighted the pivotal role played by FETP graduates during responses to significant disease outbreaks and in improving surveillance at their workplace. Other studies demonstrate the wide-ranging utility of FETPs in strengthening a country's emergency response capacity.[23] Currently, Cambodia's FETP is funded by donors, rendering it unsustainable in the long term if donors' priorities change or funding declines.[6] Therefore, government investment and strategic partnerships will be important to ensure the programme's sustainability. Sustainability could also be aided by contributions of domestic funding and by developing local and international partnerships.[2,6]

Limitations

This study has several limitations. First, it relied on self-reported responses from FETP graduates, which are subject to recall bias and social desirability bias. Respondents may have overestimated their level of engagement or underreported challenges and weaknesses. In addition, the survey used frequency categories (e.g. often, sometimes, rarely, never) to assess engagement in public health activities, which are subjective and may be interpreted differently by respondents. The survey was conducted with participants who had been enrolled across five annual cohorts, which may introduce information bias, as participants' recollections and responses might not accurately reflect their actual experiences or contributions.

Second, the study was cross-sectional, capturing data from participants at a single point in time. Only FETP graduates were included in this study; data from those who enrolled but did not finish the programme were not gathered. The viewpoints of non-completers may offer insights about obstacles to programme completion. This limits the study's ability to assess the long-term effects of FETP training, such as bringing about sustained

improvements in practice, encouraging professional development or strengthening institutional capacity. The study cannot measure the programme's actual impact on improvements in surveillance and outbreak response, but the findings describe graduates' self-reported engagement in public health activities. Future evaluations using stronger study designs and more comprehensive data collection will be important to better assess the programme's impact and to provide actionable evidence for optimizing national health security and surveillance efficiency. However, research should take a health system-level approach to assess broader institutional impacts, including national and provincial evaluations, to determine whether and how FETP graduates have strengthened the quality of surveillance and the efficiency of outbreak responses, and also to identify systemic bottlenecks and illuminate potential areas for future improvement. Strengthening data collection allows evaluations to move beyond confirming success, offering instead an evidence-based roadmap for national health security.

Third, while the study included valuable input from key stakeholders, their perspectives may not fully represent the views of all relevant actors involved in public health responses. Although semi-structured interviews were conducted, the structure of the questionnaire may have limited the depth of open-ended responses. Furthermore, the study mostly used quantitative survey data from FETP graduates, which might not fully represent the variety of viewpoints and experiences.

Lastly, the study was specifically designed to assess the contributions of FETP graduates to public health response efforts and to understand their experiences upon returning to their workplace after training. Thus, it may not capture broader aspects of training effectiveness or institutional impact.

Conclusion

FETP graduates in Cambodia have been placed throughout the country's public health system, especially at the provincial and district levels, where they contribute to surveillance and outbreak responses. Findings suggest that FETP graduates are involved in a broad range of public health functions; however, frequent engagement was reported for relatively few activities. Nonetheless, stakeholders emphasized that FETP graduates have played an important role in key public health response efforts, particularly in conducting outbreak investigations and improving surveillance systems. This reflects both the ongoing contributions of the programme and the need to further strengthen engagement and capacity across all levels of training. Importantly, increased domestic funding would help to support the programme's long-term sustainability and reinforce government ownership of field epidemiology capacity in Cambodia.

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During the preparation of this manuscript, the authors used ChatGPT (version 4.0/OpenAI) for language editing and improving clarity. The authors reviewed, validated and edited every piece of content altered by ChatGPT. The work's originality, accuracy and integrity are entirely the authors' responsibility.

Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

The study received ethical approval from the National Ethical Committee for Health Research, MOH Cambodia (approval no. 380NECHR, November 2024). Written informed consent was obtained from all participants.

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Knowledge, attitudes and practices regarding antibiotic use in chicken farming in a rural area of Viet Nam, 2023–2024

Nguyen Lan Vy,[a] Nguyen Manh Hung[b] and Pham-Duc Phuc[c,d]

Correspondence to Nguyen Manh Hung (email: hung_iebr@yahoo.com or hung@ib.ac.vn)

Objective: Antibiotic misuse in animal husbandry contributes to antimicrobial resistance, a major public health concern. This study assessed the knowledge, attitudes and practices (KAPs) regarding antibiotic use in chicken farming among residents of a rural community in northern Viet Nam.

Methods: A cross-sectional study combining quantitative and qualitative methods was conducted from October 2023 to August 2024, comprising a survey of 264 chicken farmers and 20 in-depth interviews.

Results: Overall, 211 (79.9%) respondents had incomplete knowledge about antibiotic use, 161 (61.0%) exhibited attitudes that could potentially contribute to inappropriate antibiotic use, and 217 (82.2%) reported unsafe practices related to antibiotic use. In multivariable logistic regression analysis, annual household income, farming method, farming system, educational attainment, poultry disease experience and chicken feeding practices were independently associated with one or more KAP outcomes.

Discussion: Inappropriate antibiotic use was common among farmers. Community-based training, improved veterinary support and stronger regulations are needed to promote rational antibiotic use and reduce the risks of antimicrobial resistance.

Antibiotics have transformed the treatment of bacterial infections in humans and animals. However, their misuse in animal husbandry has accelerated antimicrobial resistance (AMR), which threatens public health and food safety.[1] AMR occurs when bacteria become resistant to antibiotics, making infections more difficult to treat and increasing the risk of disease transmission, severe illness and mortality.[2]

Globally, livestock account for a significant portion of antibiotic use, with poultry farming being a major contributor.[3,4] In Viet Nam, antibiotics are widely used in small-scale chicken farming, where veterinary supervision is often limited. Many farmers administer antibiotics without professional guidance, increasing the risk of inappropriate use and development of AMR.[5] Misuse is driven by easy access to antibiotics, economic pressures and limited awareness of proper use.

Previous studies have shown that farmers often lack knowledge about antibiotic indications, dosages and withdrawal periods.[6–14] Misconceptions are common, such as the beliefs that antibiotics should be used for all diseases and that higher doses improve recovery. Understanding the knowledge, attitudes and practices (KAPs) of chicken farmers is therefore essential for designing effective interventions.

This study aims to assess KAPs regarding antibiotic use in chicken farming in a rural community in northern Viet Nam, and to identify key factors associated with inappropriate use.

[a] National Institute for Control of Vaccines and Biologicals, Hanoi, Viet Nam.
[b] Institute of Biology, Graduate University of Science and Technology, Vietnam Academy of Science and Technology, Hanoi, Viet Nam.
[c] Center for Public Health and Ecosystem Research, Hanoi University of Public Health, Hanoi, Viet Nam.
[d] Institute of Environmental Health and Sustainable Development, Hanoi, Viet Nam.
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METHODS

Study site

This study was conducted in Lau Thuong Commune, Thai Nguyen Province, Viet Nam, a rural mountainous area where small-scale poultry farming is a major source of livelihood. Chickens are typically raised in free-range or semi-intensive systems using traditional practices. Veterinary drugs are frequently purchased informally without professional guidance, and access to veterinary services is limited.[14] These conditions reflect settings where unregulated antibiotic use contributes to AMR.

Study design and population

A cross-sectional mixed-methods study was conducted from October 2023 to August 2024 among chicken farmers aged ≥18 years who were involved in chicken management and decision-making about antibiotic use.

Sampling methods

Stratified random sampling was applied to ensure representation across demographic groups, village clusters and farm-scale categories within the commune. A list of eligible chicken farms was obtained from the local veterinary authority, which maintains records of livestock-keeping households for vaccination and disease management purposes. The list was updated before sampling and was considered to include all active chicken farms in the study area.

Farms were stratified by village and farm size (≤50, 51–1000, >1000 chickens). The number of farmers selected from each village was proportional to the total number of eligible households in that village. Within each stratum, systematic random sampling was used to select participants from the official list. Sample size was calculated using the formula:

$$n = \frac{Z^2_{1-\frac{\alpha}{2}} \times P \times (1-P)}{d^2},$$

where n is the minimum sample size; $Z = 1.96$ (95% confidence level, with $\alpha = 0.05$); P is the estimated prevalence; and d is the desired margin of error (set at 5%). Based on Pham-Duc et al., the estimated prevalence of incomplete knowledge, attitudes that could contribute to inappropriate antibiotic use, and poor practices was 0.80, 0.86 and 0.87, respectively.[2] These values yielded minimum required sample sizes of 246, 185 and 174, respectively. To ensure adequate representation, the largest value (246) was selected and adjusted for a 5% non-response rate. The sample size was calculated as:

$$n_{\text{adjusted}} = \frac{246}{1 - 0.05} \approx 259.$$

In total, 264 farmers were invited from a list of 580 eligible chicken farms to respond to the structured questionaire.

For the qualitative component, 20 in-depth interviews were conducted using purposive sampling.

Data collection tools

Quantitative data were collected using a structured questionnaire adapted from validated KAP surveys on antibiotic use in Viet Nam.[2,8,12] The questionnaire consisted of four sections: (i) demographic information (15 items), and (ii) knowledge (15 items), (iii) attitudes (12 items) and (iv) practices (18 items) related to antibiotic use (Supplementary Material). The questionnaire was pre-tested with 20 farmers outside the study area to ensure clarity, cultural relevance and reliability. Although internal consistency was not formally assessed, the questionnaire was adapted from previously validated tools.[2,4] Correct responses are provided in **Supplementary Tables 1–3**.

Qualitative data were collected through semi-structured interviews focusing on each participant's perceptions, decision-making processes and barriers to appropriate antibiotic use. The interview guide was adapted from previous studies.[15,16] Interviews were conducted in Vietnamese, audio-recorded with participant consent, transcribed verbatim and anonymized.

Each interview lasted 30–40 minutes and was conducted by a main interviewer with one or two note-takers. Participants were purposively selected to ensure diversity in farm size, farming experience and antibiotic use practices.

For the quantitative analysis, correct knowledge responses were scored as 1 and incorrect or unknown responses as 0. Attitude and practice items (Likert scale or multiple choice) were coded as 1 if appropriate or 0 if inappropriate or incorrect based on recommended

guidelines and prior studies.[2,4] Domain scores were summed and converted to percentages of the maximum possible score. A threshold of ≥75% was used to classify adequate knowledge, appropriate attitudes and appropriate practices, as has been used in previous research,[2] corresponding to scores of ≥11, ≥9 and ≥14, respectively. Missing responses were rare and were coded as incorrect to avoid overestimation.

Data management and quality control

Data were collected by trained researchers following standardized procedures. Completed questionnaires were checked daily for completeness and accuracy and double-entered into a secure Excel database (Microsoft Corporation, Redmond, WA, USA). Qualitative transcripts were cross-checked against audio recordings to ensure fidelity. All data were stored securely, and confidentiality was strictly maintained.

Data analysis

Quantitative data were analysed using SPSS (version 28.0). Descriptive statistics summarized demographic characteristics and KAP outcomes. Univariate analyses (χ^2 test or Fisher's exact test, as appropriate) were performed to identify factors associated with KAPs regarding antibiotic use. Variables with $P \leq 0.05$ in univariate analysis, together with variables considered theoretically relevant based on previous studies, were included in multivariable logistic regression models. Knowledge and attitudes were additionally retained in the practice model because of their epidemiological relevance in the KAP framework. Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were calculated. Statistical significance was set at $P < 0.05$.

Qualitative data were analysed thematically using NVivo software.[17,18] Transcripts were coded inductively, and emerging codes were grouped into categories and overarching themes to capture farmers' perceptions and decision-making related to antibiotic use.

RESULTS

Participant characteristics

All 264 selected farmers provided informed consent before the interview, resulting in a 100% response rate. Of the respondents, 141 (53.4%) were male. Most participants were aged >35 years (224, 84.8%), and 135 (51.1%) belonged to the Kinh ethnic group, while 129 (48.9%) were from ethnic minorities. The majority had secondary education (181, 68.6%), and 191 (72.3%) reported household income below the local average. Poultry farming was the main income source for 154 (58.3%) participants, and 179 (67.8%) had more than 10 years of farming experience (**Table 1**).

Altogether, 203 (76.9%) farmers reported their chickens had experienced diseases in the past 12 months, and 164 (62.1%) reported having only irregular access to veterinary services. Most households practised mixed farming (230, 87.1%) and raised chickens mainly for meat (112, 42.4%) or eggs (102, 38.6%) (data not shown). Semi-free-range or combined systems were common, and 116 (43.9%) used household food waste as feed (data not shown).

Knowledge, attitudes and practices

Knowledge

Overall, 178 (67.4%) farmers had heard of antibiotics, but only 24 (9.1%) had received formal training in their use (**Table 2**). Most respondents knew that antibiotics treat bacterial infections (205, 77.7%) and should be used by prescription or under professional guidance (225, 85.2%). In addition, 203 (76.9%) respondents were aware that inappropriate use, such as incorrect dosing, misuse and failure to follow professional guidance, could result in financial losses for farmers. These losses may arise from unnecessary expenditure on antibiotics, reduced treatment effectiveness due to inappropriate use, and additional costs associated with treating diseases linked to AMR. Furthermore, 162 (61.4%) acknowledged that the misuse of antibiotics in animals may reduce their effectiveness in humans.

Several misconceptions were also identified. Approximately half of respondents (134, 50.8%) believed that antibiotics could treat all animal diseases, while 120 (45.5%) considered antibiotics to be appropriate for promoting animal growth. Furthermore, 105 (39.8%) believed that antibiotics have no side-effects. Misunderstandings regarding appropriate treatment practices were also common, with 147 (55.7%) indicating that the dosage and frequency of antibiotics should be increased if chickens do not improve, and 155 (58.7%) reporting that antibiotics could be stopped once

Table 1. **Characteristics of study respondents, Lau Thuong Commune, Viet Nam (*N* = 264)**

Characteristics	No. (%)
Sex	
Male	141 (53.4)
Female	123 (46.6)
Age group (years)	
≤35	40 (15.2)
36–54	115 (43.6)
≥55	109 (41.2)
Ethnic group	
Kinh	135 (51.1)
Other minorities (Cao Lan, Dao, Keo, Muong, Nung, San Diu, Tay, Thai)	129 (48.9)
Educational attainment	
Primary school or below	51 (19.3)
Secondary school	181 (68.6)
Tertiary education	32 (12.1)
Annual household income	
Below local average	191 (72.3)
Above local average	73 (27.7)
Primary source of income	
Poultry farming	154 (58.3)
Other	110 (41.7)
Farming experience	
≤10 years	85 (32.2)
>10 years	179 (67.8)
Experience with poultry diseases	
Within past 12 months	203 (76.9)
More than 12 months ago	61 (23.1)
Access to veterinary services	
Regular (obtain veterinary consultation whenever needed)	100 (37.9)
Irregular (only occasional or no access to professional veterinary services)	164 (62.1)

chickens appear to recover. Taken together, 211 (79.9%) respondents demonstrated incomplete knowledge regarding appropriate antibiotic use (data not shown).

Interviews suggested that some farmers perceived antibiotic use as unavoidable in chicken production. For example, one participant stated that it is impossible to raise chickens without using antibiotics (**Supplementary Table 4**). This perception may encourage widespread reliance on antibiotics observed in the survey.

Attitudes

In general, attitudes towards antibiotic use were mixed (**Table 3**). Of the 264 participants, 161 (61.0%) had at least one incorrect response in the attitude questionnaire, indicating attitudes that could potentially contribute to inappropriate antibiotic use (data not shown).

Most farmers recognized the importance of antibiotics for treating diseases in livestock production,

Table 2. **Knowledge of chicken farmers regarding antibiotic use in chicken production, Lau Thuong Commune, Viet Nam (*N* = 264)**

Knowledge statement	No. (%) responses	
	Yes	No
General awareness and exposure to training		
Heard of/aware of antibiotics	178 (67.4)	86 (32.6)
Participated in training on antibiotic use	24 (9.1)	240 (90.9)
	Correct	**Incorrect**
Knowledge regarding purposes and principles of antibiotic use		
Antibiotics can treat all animal diseases.	130 (49.2)	134 (50.8)
Antibiotics can be used to treat bacterial infections.	205 (77.7)	59 (22.3)
Antibiotics should be used for disease prevention in chicken farming.	65 (24.6)	199 (75.4)
Antibiotics should be used to promote animal growth.	144 (54.5)	120 (45.5)
Antibiotics have no side-effects.	159 (60.2)	105 (39.8)
Antibiotics should be used according to prescription or professional guidance.	225 (85.2)	39 (14.8)
Antibiotics can be used based on personal experience; veterinary advice is only needed when animals are severely ill.	118 (44.7)	146 (55.3)
The dosage and frequency of antibiotics should be increased if chickens do not improve.	117 (44.3)	147 (55.7)
Antibiotics can be stopped once chickens appear to recover.	109 (41.3)	155 (58.7)
Inappropriate antibiotic use is associated with financial loss for farmers.	203 (76.9)	61 (23.1)
Misuse of antibiotics in animals may reduce antibiotic effectiveness in humans.	162 (61.4)	102 (38.6)

with 209 (79.2%) agreeing or strongly agreeing that antibiotic treatment is important in animal husbandry. Similarly, 223 (84.5%) agreed or strongly agreed that antibiotic use in chickens requires consultation with a veterinarian or animal health worker, and 230 (87.1%) agreed or strongly agreed that a veterinary prescription is required when using antibiotics.

However, several misconceptions were identified. More than half of the respondents (170, 64.4%) believed that antibiotics can treat all diseases in animals, and 164 (62.1%) agreed or strongly agreed that antibiotics are necessary to improve livestock productivity. In addition, 156 (59.1%) believed that antibiotics should be changed immediately if chickens do not improve, while 129 (48.9%) considered it acceptable to increase antibiotic dosage arbitrarily to accelerate recovery.

Despite these misconceptions, awareness of withdrawal periods before slaughter was relatively high, with 236 (89.4%) agreeing that antibiotics should be stopped before selling chickens for slaughter. Collectively, 161 (61.0%) exhibited attitudes that could potentially contribute to inappropriate antibiotic use (data not shown).

Preventive use of antibiotics and other medications was frequently reported during interviews. Some farmers routinely administered vaccines and antibiotics, and used disinfectants as part of disease prevention, while others reported frequent use of antibiotics and disinfectants even in the absence of confirmed illness. The use of human medicines for treating livestock was also noted (**Supplementary Table 4**). These findings indicate a widespread reliance on preventive medication, self-prescription and non-veterinary treatment sources, consistent with the quantitative results showing frequent inappropriate antibiotic practices.

Practices

Antibiotics were most commonly used when chickens were diagnosed with disease (184, 69.7%) or showed abnormal clinical signs (160, 60.6%) (**Table 4**). However, a small proportion of farmers also reported using antibiotics for non-disease conditions, such as

Table 3. **Attitudes of chicken farmers towards antibiotic use in chicken production, Lau Thuong Commune, Viet Nam (*N* = 264)**

Statement	No. (%) participants				
	Strongly disagree	Disagree	Neutral/no opinion	Agree	Strongly agree
Antibiotics help prevent and treat diseases in humans and animals.	16 (6.0)	41 (15.6)	23 (8.7)	150 (56.8)	34 (12.9)
Antibiotics can treat all diseases in animals/livestock.	8 (3.0)	53 (20.1)	33 (12.5)	137 (51.9)	33 (12.5)
Antibiotics are necessary to improve livestock productivity.	11 (4.1)	55 (20.8)	34 (12.9)	124 (47.0)	40 (15.2)
Antibiotic use is important for treating diseases in livestock production.	9 (3.4)	24 (9.1)	22 (8.3)	156 (59.1)	53 (20.1)
Antibiotic use is important for promoting growth in livestock.	19 (7.2)	90 (34.1)	29 (11.0)	84 (31.8)	42 (15.9)
It is necessary to change the type of antibiotic immediately if the animal does not improve.	16 (6.0)	68 (25.8)	24 (9.1)	127 (48.1)	29 (11.0)
To help chickens recover faster, antibiotic dosage can be increased arbitrarily.	24 (9.1)	87 (32.9)	24 (9.1)	108 (40.9)	21 (8.0)
When antibiotics are used correctly, there is little risk of antibiotic resistance.	6 (2.3)	21 (8.0)	26 (9.8)	161 (61.0)	50 (18.9)
Antibiotic use in chickens requires consultation with a veterinarian or animal health worker.	2 (0.8)	18 (6.8)	21 (8.0)	126 (47.7)	97 (36.7)
Antibiotic use in chickens requires a prescription from a veterinarian or animal health worker.	3 (1.1)	18 (6.8)	13 (5.0)	143 (54.1)	87 (33.0)
When an animal has a disease that cannot be treated with antibiotics, it is extremely dangerous.	5 (1.9)	29 (11.0)	13 (5.0)	151 (57.2)	66 (25.1)
Stopping antibiotic use before selling chickens (for slaughter) is necessary.	6 (2.3)	16 (6.0)	6 (2.3)	114 (43.2)	122 (46.2)

slow growth (13, 4.9%), weather changes (15, 5.7%) or when disease was reported in nearby farms (26, 9.8%).

Farmers relied mainly on their own experience when selecting and using antibiotics (94, 35.6%) or veterinary officers (86, 32.6%), while fewer reported consulting veterinary pharmacists (28, 10.6%) or other farmers (18, 6.8%). About half of respondents (135, 51.1%) reported purchasing antibiotics without receiving a prescription or professional consultation.

In terms of antibiotic management, most farmers reported checking the expiry date before use (220, 83.3%) and not using expired antibiotics (246, 93.2%). Nevertheless, inappropriate practices were observed, including disposing of antibiotics in household garbage (139, 52.7%) and using human antibiotics for animals (65, 24.6%). Record-keeping related to chicken management was generally poor, with 212 (80.3%) farmers reporting that they did not keep any records. Altogether, 217 (82.2%) reported unsafe practices related to antibiotic use (data not shown).

Interviews revealed several inappropriate antibiotic use practices consistent with the quantitative findings. Many farmers purchased antibiotics directly from veterinary pharmacies without veterinary consultation and used them based on personal experience (**Supplementary Table 4**). Others relied on experience or informal information sources when treating disease. Routine or seasonal antibiotic use for disease prevention was also common. Although some farmers reported consulting veterinary officers, treatment practices were often inconsistent and poorly documented. These findings suggest that antibiotic use decisions were frequently based on convenience, experience and accessibility rather than professional guidance, which might contribute to the high prevalence of inappropriate practices observed in the survey.

Factors associated with KAPs

Univariate and multivariable logistic regression analyses identified several factors significantly associated with KAPs regarding antibiotic use (**Table 5**). Age, ethnicity and

Table 4. **Practices of chicken farmers regarding antibiotic use and management in chicken production, Lau Thuong Commune, Viet Nam (*N* = 264)**

Practice	Category	No. (%)
Antibiotic use		
Occasions for antibiotic use	Diagnosed disease	184 (69.7)
	Abnormal clinical signs	160 (60.6)
	Disease reported in nearby farms	26 (9.8)
	Weather changes	15 (5.7)
	Slow growth (without signs of disease)	13 (4.9)
	Do not use antibiotics	16 (6.1)
Sources of advice for antibiotic selection and use	Personal experience	94 (35.6)
	Veterinary officer	86 (32.6)
	Veterinary pharmacists	28 (10.6)
	Other farmers	18 (6.8)
	Other sources	17 (6.4)
	Relatives	9 (3.4)
	Drug company representatives	6 (2.3)
	Friends	6 (2.3)
Prescription or professional consultation when purchasing antibiotics	Yes	129 (48.9)
	No	135 (51.1)
Factors considered when choosing antibiotics	Remaining shelf life (longer time before expiration)	144 (54.5)
	Trusted pharmacy	54 (20.5)
	Advice from veterinary pharmacists	44 (16.7)
	Specific pharmaceutical company	14 (5.3)
	Advice from family/friends	4 (1.5)
	Other	4 (1.5)
Antibiotic management		
Antibiotic storage location	Medicine cabinet	88 (33.3)
	Anywhere	67 (25.4)
	Refrigerator	60 (22.7)
	Chicken coop	42 (15.9)
	Other	7 (2.7)
Check antibiotic expiry date before use	Yes	220 (83.3)
	No	44 (16.7)
Practice when antibiotics expire	Stop using	246 (93.2)
	Continue using (higher dose)	17 (6.4)
	Other	1 (0.4)
Length of withdrawal period before selling chickens	<2 days	16 (6.1)
	2 days	1 (0.4)
	5 days	7 (2.7)
	>5 days	240 (90.9)

sex were not significantly associated with KAP outcomes. Higher annual household income was independently associated with satisfactory knowledge (aOR: 3.33, 95% CI: 1.12–8.89; $P = 0.02$) and appropriate antibiotic use practices (aOR: 2.92, 95% CI: 1.27–5.86; $P = 0.02$). In univariate analysis, farmers with more than 10 years of experience in chicken farming had lower odds of satisfactory knowledge (OR: 0.49, 95% CI: 0.30–0.90;

Practice	Category	No. (%)
Disposal of leftover antibiotics	Household garbage	139 (52.7)
	Burning	59 (22.3)
	Keep for future use	40 (15.2)
	Give to neighbours/other farms	15 (5.7)
	Bury	11 (4.2)
Record-keeping for chicken management	No records kept	212 (80.3)
	Vaccination records	31 (11.7)
	Breeds	4 (1.5)
	Information about buyer	4 (1.5)
	Flock size	3 (1.1)
	Antibiotic use	3 (1.1)
	Feed	2 (0.8)
	No. of times disinfectant used	2 (0.8)
	Other	3 (1.1)
Use of human antibiotics for animals	Yes	65 (24.6)
	No	199 (75.4)

P = 0.02) and appropriate antibiotic use practices (OR: 0.52, 95% CI: 0.27–0.99; P = 0.05) than those with less experience; however, these associations were no longer statistically significant after adjustment. In addition, farmers raising chickens together with other animals (polyculture) had lower odds of satisfactory knowledge and appropriate antibiotic use practices (both aOR: 0.16, 95% CI: 0.04–0.67; P = 0.03) than those raising chickens only.

Higher educational attainment was independently associated with appropriate antibiotic use practices (aOR: 4.22, 95% CI: 1.46–9.64; P = 0.02). Farmers whose chickens had experienced disease more than 12 months previously had higher odds of appropriate antibiotic use practices than those whose flocks had experienced disease within the past 12 months (aOR: 2.86, 95% CI: 1.04–7.63; P = 0.03). In addition, farmers using combined cage and semi-free-range systems had higher odds of desirable attitudes towards antibiotic use than those using caged systems (aOR: 3.34, 95% CI: 1.14–9.17; P = 0.03). Feeding practices were also significantly associated with KAP outcomes, particularly among farmers using household waste or a combination of commercial feed and household waste.

Neither knowledge (OR: 0.78, 95% CI: 0.34–1.80; P = 0.57) nor attitude (OR: 0.61, 95% CI: 0.31–1.23; P = 0.17) was significantly associated with antibiotic use practices (**Table 5**).

Overall, higher annual household income was independently associated with satisfactory knowledge and satisfactory practices, whereas farming method and feeding practices were associated with both knowledge and practices.

DISCUSSION

This study reveals substantial gaps in KAPs regarding antibiotic use among chicken farmers in Lau Thuong Commune. Inadequate knowledge, attitudes that may lead to inappropriate antibiotic use, and unsafe practices were common. Several socioeconomic and farming-related characteristics, including household income, farming experience, educational attainment, farming systems and feeding practices, were associated with KAP outcomes.

The high prevalence of inadequate knowledge may indicate limitations in farmers' understanding of antibiotic indications, dosing and withdrawal periods. Similar findings have been reported across Viet Nam and in other low- and middle-income countries (LMICs), where misconceptions about antibiotic effectiveness and safe use remain common among small-scale chicken producers.[1,2,4]

Table 5. **Univariate and multivariable logistic regression analyses of factors associated with knowledge, attitudes and practices regarding antibiotic use among chicken farmers, Lau Thuong Commune, Viet Nam (*N* = 264)**

Variable	Category	Unsatisfactory *n* (%)	Satisfactory *n* (%)	Crude OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
Knowledge							
Sex	Male	111 (42.0)	30 (11.4)	Reference	–		
	Female	100 (37.9)	23 (8.7)	0.85 (0.46–1.56)	0.60		
Age group (years)	≤35	30 (11.4)	10 (3.8)	Reference	–		
	36–54	93 (35.2)	22 (8.3)	0.71 (0.30–1.70)	0.50		
	≥55	88 (33.3)	21 (8.0)	0.72 (0.30–1.70)	0.50		
Ethnicity	Kinh	111 (42.0)	24 (9.1)	Reference	–		
	Other ethnicities	100 (37.9)	29 (11.0)	1.34 (0.70–2.50)	0.36		
Educational attainment	Primary school or below	42 (15.9)	9 (3.4)	Reference	–		
	Secondary school	144 (54.5)	37 (14.0)	1.20 (0.50–2.80)	0.67		
	Tertiary education	25 (9.5)	7 (2.7)	1.31 (0.40–4.10)	0.64		
Annual household income	Below local average	164 (62.1)	27 (10.2)	Reference	–	Reference	–
	Above local average	47 (17.8)	26 (9.8)	3.36 (1.80–6.10)	**<0.01**	3.33 (1.12–8.89)	**0.02**
Farming experience (years)	≤10	61 (23.1)	24 (9.1)	Reference	–	Reference	–
	>10	150 (56.8)	29 (11.0)	0.49 (0.30–0.90)	**0.02**	0.47 (0.24–1.13)	0.06
Experience with poultry diseases	Within past 12 months	164 (62.1)	39 (14.8)	Reference	–		
	More than 12 months ago	47 (17.8)	14 (5.3)	1.30 (0.60–2.40)	0.52		
Farming method (mono- or poly-culture)	Raising chickens only	14 (5.3)	20 (7.6)	Reference	–	Reference	–
	Raising chickens with other animals	197 (74.6)	33 (12.5)	0.12 (0.06–0.26)	**<0.01**	0.16 (0.04–0.67)	**0.03**
Farming system	Caged	17 (6.4)	9 (3.4)	Reference	–		
	Semi-free-range	70 (26.5)	14 (5.3)	0.40 (0.20–1.20)	0.12		
	Combined caged and semi-free-range	122 (46.2)	30 (11.4)	0.50 (0.20–1.30)	0.16		
Chicken feed	Commercial feed	32 (12.1)	22 (8.3)	Reference	–	Reference	–
	Household waste	84 (31.8)	12 (4.5)	0.21 (0.09–0.47)	**<0.01**	0.20 (0.08–0.49)	**0.04**
	Combined commercial feed and household waste	97 (36.7)	19 (7.2)	0.28 (0.14–0.59)	**<0.01**	0.26 (0.12–0.81)	**0.03**

Variable	Category	Unsatisfactory *n* (%)	Satisfactory *n* (%)	Crude OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
Attitudes							
Sex	Male	87 (33.0)	54 (20.5)	Reference	–		
	Female	74 (28.0)	49 (18.5)	1.07 (0.65–1.75)	0.80		
Age group (years)	≤35	27 (10.2)	13 (4.9)	Reference	–		
	36–54	69 (26.1)	46 (17.4)	1.40 (0.70–3.00)	0.45		
	≥55	65 (24.6)	44 (16.7)	1.40 (0.70–3.00)	0.45		
Ethnicity	Kinh	89 (33.7)	46 (17.4)	Reference	–		
	Other ethnicities	72 (27.3)	57 (21.6)	1.50 (0.90–2.50)	0.10		
Educational attainment	Primary school or below	36 (13.6)	15 (5.7)	Reference	–		
	Secondary school	104 (39.4)	77 (29.2)	1.80 (0.90–3.60)	0.10		
	Tertiary education	21 (8.0)	11 (4.2)	1.26 (0.49–3.24)	0.64		
Annual household income	Below local average	119 (45.1)	72 (27.3)	Reference	–		
	Above local average	42 (15.9)	31 (11.7)	1.22 (0.70–2.11)	0.48		
Farming experience (years)	≤10	59 (22.3)	26 (9.8)	Reference	–		
	>10	102 (38.6)	77 (29.2)	1.71 (0.99–2.96)	0.06		
Experience with poultry diseases	Within past 12 months	126 (47.7)	77 (29.2)	Reference	–		
	More than 12 months ago	35 (13.3)	26 (9.8)	1.20 (0.70–2.20)	0.51		
Farming method (mono- or poly-culture)	Raising chickens only	16 (6.1)	18 (6.8)	Reference	–		
	Raising chickens with other animals	145 (54.9)	85 (32.2)	0.52 (0.25–1.08)	0.09		
Farming system	Caged	21 (8.0)	5 (1.9)	Reference	–	Reference	–
	Semi-free-range	57 (21.6)	28 (10.6)	2.10 (0.70–6.00)	0.19	2.21 (0.94–4.98)	0.34
	Combined cage and semi-free-range	83 (31.4)	70 (26.5)	3.50 (1.30–9.90)	**0.02**	3.34 (1.14–9.17)	**0.03**
Chicken feed	Commercial feed	15 (5.7)	18 (6.8)	Reference	–	Reference	–
	Household waste	82 (31.1)	34 (12.9)	0.35 (0.15–0.82)	**0.02**	0.42 (0.12–0.94)	**0.04**
	Combined commercial feed and household waste	64 (24.2)	51 (19.3)	0.66 (0.29–1.47)	0.32	0.84 (0.16–1.62)	0.12
Practices							
Sex	Male	114 (43.2)	27 (10.2)	Reference	–		
	Female	103 (39.0)	20 (7.6)	0.85 (0.46–1.56)	0.60		

Variable	Category	Unsatisfactory *n* (%)	Satisfactory *n* (%)	Crude OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
Age group (years)	≤35	33 (12.5)	7 (2.7)	Reference	–		
	36–54	88 (33.3)	27 (10.2)	1.50 (0.60–3.60)	0.51		
	≥55	96 (36.4)	13 (4.9)	0.60 (0.20–1.70)	0.42		
Ethnicity	Kinh	110 (41.7)	25 (9.5)	Reference	–		
	Other ethnicities	107 (40.5)	22 (8.3)	0.90 (0.50–1.70)	0.87		
Educational attainment	Primary school or below	45 (17.0)	6 (2.3)	Reference	–	Reference	–
	Secondary school	153 (58.0)	28 (10.6)	1.37 (0.50–3.60)	0.53	1.04 (0.41–2.12)	0.72
	Tertiary education	19 (7.2)	13 (4.9)	5.13 (1.73–15.20)	**<0.01**	4.22 (1.46–9.64)	**0.02**
Annual household income	Below local average	168 (63.6)	23 (8.7)	Reference	–	Reference	–
	Above local average	49 (18.6)	24 (9.1)	3.58 (1.86–6.88)	**<0.01**	2.92 (1.27–5.86)	0.02
Farming experience (years)	≤10	64 (24.2)	21 (8.0)	Reference	–	Reference	–
	>10	153 (58.0)	26 (9.8)	0.52 (0.27–0.99)	0.05	0.58 (0.09–1.93)	0.12
Experience with poultry diseases	Within past 12 months	176 (66.7)	27 (10.2)	Reference	–	Reference	–
	More than 12 months ago	41 (15.5)	20 (7.6)	3.18 (1.63–6.22)	**<0.01**	2.86 (1.04–7.63)	**0.03**
Farming method (mono- or poly-culture)	Raising chickens only	14 (5.3)	20 (7.6)	Reference	–	Reference	–
	Raising chickens with other animals	203 (76.9)	27 (10.2)	0.09 (0.04–0.21)	**<0.01**	0.16 (0.04–0.67)	**0.03**
Farming system	Caged	15 (5.7)	11 (4.2)	Reference	–	Reference	–
	Semi-free-range	71 (26.9)	14 (5.3)	0.27 (0.10–0.72)	**<0.01**	0.24 (0.08–0.77)	**0.01**
	Combined cage and semi-free-range	131 (49.6)	22 (8.3)	0.23 (0.09–0.57)	**<0.01**	0.20 (0.08–0.51)	**0.01**
Chicken feed	Commercial feed	12 (4.5)	21 (8.0)	Reference	–	Reference	–
	Household waste	119 (45.1)	5 (1.9)	0.02 (0.01–0.08)	**<0.01**	0.10 (0.08–0.59)	**0.02**
	Combined commercial feed and household waste	86 (32.6)	21 (8.0)	0.14 (0.06–0.36)	**<0.01**	0.21 (0.09–0.86)	**0.03**
Knowledge on antibiotic use	Sufficient	45 (17.0)	8 (3.0)	Reference	–	Reference	–
	Insufficient	172 (65.2)	39 (14.8)	0.78 (0.34–1.80)	0.57	0.81 (0.42–2.13)	0.62
Attitudes towards antibiotic use	Desirable	169 (64.0)	32 (12.1)	Reference	–	Reference	–
	Undesirable	48 (18.2)	15 (5.7)	0.61 (0.31–1.23)	0.17	0.65 (0.27–1.81)	0.21

CI: confidence interval; OR: odds ratio.

Bold *P* values indicate statistical significance (<0.05).

ORs were estimated using logistic regression with satisfactory knowledge, attitudes or practices (KAPs) as the outcome. Therefore, OR >1 indicates higher odds of satisfactory KAPs, whereas OR <1 indicates lower odds of satisfactory KAPs.

Although ethnicity was not significantly associated with KAP outcomes in this study, ethnic minority populations in rural Viet Nam may face barriers to education, veterinary services and health information, particularly in remote areas. Therefore, communication strategies should consider local cultural and language contexts.[2] These disparities may reflect broader systemic challenges, including limited veterinary extension services and insufficient dissemination of evidence-based guidelines.[19] Without addressing these constraints, inappropriate antibiotic use may persist and contribute to AMR.

Misconceptions were common, particularly the beliefs that antibiotics can treat all animal diseases and that higher doses accelerate recovery (**Tables 2–4**), consistent with previous studies.[20] Limited awareness of withdrawal periods raises concerns about antibiotic residues in chicken products and potential public health risks.[1] Although regulations exist in Viet Nam,[5] their implementation among small-scale farmers remains limited.

Attitudes that could contribute to inappropriate antibiotic use were also common, especially the tendency to change an antibiotic immediately after treatment failure. This may lead to incomplete treatment courses and irrational drug selection, contributing to AMR.[19] In small-scale production systems, concerns about disease-related financial loss may encourage preventive or unsupervised antibiotic use.[19] Evidence from other LMICs suggested that community-based training combined with improved veterinary services can strengthen antibiotic stewardship, defined as improving the appropriate use of antibiotics (i.e. the right drug, timing and duration).[1,21]

Unsafe practices were widely reported, including antibiotic administration without veterinary consultation and prophylactic use without clear clinical indication, consistent with earlier studies in rural Viet Nam.[4] Lower educational attainment and lower household income were associated with less appropriate antibiotic use practices, consistent with findings from other LMIC settings.[22] Financial constraints may further discourage seeking professional advice, potentially reinforcing reliance on self-directed antibiotic use. The multivariable analysis further showed that higher household income was independently associated with better knowledge and more appropriate antibiotic use practices. In contrast, farmers raising chickens together with other livestock had lower odds of satisfactory knowledge and appropriate practices, possibly because antibiotics available on the farm may be used interchangeably across species without veterinary guidance. These findings suggest that educational and veterinary support interventions should particularly target small-scale mixed-livestock farms. Although knowledge and attitudes are generally considered important determinants of behaviour, neither was significantly associated with antibiotic use practices in the present study. This finding suggests that improving knowledge alone may be insufficient to change farmers' behaviours, particularly when antibiotic use decisions are constrained by economic pressures, farming conditions and access to veterinary services. Similar observations have been reported in previous KAP studies, where structural and contextual factors often outweighed individual knowledge in shaping antibiotic use practices.[2,14]

Structural factors may further contribute to inappropriate antibiotic use. Limited access to veterinary services and weak enforcement of regulations may facilitate the unregulated availability of antibiotics in livestock production. Strengthening the veterinary system and regulatory enforcement could help reduce misuse. Viet Nam's National Action Plan on AMR (2023–2030) provides a One Health framework for coordinated interventions across sectors.[23]

The qualitative findings complemented the quantitative results by showing that antibiotic use decisions were often shaped by practical constraints rather than knowledge alone. Farmers described frequent disease occurrence, economic pressure and limited access to veterinary support as reasons for using antibiotics routinely or without professional guidance. Some participants believed that chicken production is difficult without antibiotics, while others relied on personal experience or advice from veterinary pharmacists. These insights suggest that inappropriate use reflects a combination of behavioural and structural factors, requiring multifaceted interventions.

These results have practical implications. Educational interventions should target farmers with lower educational attainment and those facing barriers to accessing veterinary services and reliable antibiotic-related information. Efforts to improve affordable veterinary support and strengthen prescription regulations may also help promote rational antibiotic use. Experiences from other WHO regions indicate that coordinated surveillance, stewardship programmes and regulatory enforcement can

reduce antibiotic use in agriculture, although adaptation to local contexts is necessary.[24]

Limitations

This study has several limitations. Its cross-sectional design precludes causal inference, and self-reported data may be subject to recall and social desirability biases. The use of predefined KAP cut-offs may have led to some misclassification, particularly for respondents with borderline scores. Logistic regression was used to estimate associations; however, for common outcomes, odds ratios may overestimate effect sizes. Alternative approaches, such as Poisson regression with robust variance, may provide more accurate estimates. Despite these limitations, the study provides valuable insights into antibiotic use among small-scale chicken farmers in rural Viet Nam.

Conclusions

This study highlights notable gaps in KAPs regarding antibiotic use among chicken farmers in Lau Thuong Commune. Inadequate knowledge, attitudes that may lead to inappropriate antibiotic use, and unsafe practices were common, while socioeconomic and farming-related factors influenced KAP outcomes. These findings underscore the need for context-specific interventions that combine farmer education, improved veterinary support and stronger regulatory oversight to promote rational antibiotic use and reduce the risk of AMR.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

This study was approved in accordance with Decision No. 99/2024/YTCC-HD3 by the Institutional Review Board of the Hanoi University of Public Health. All methods were conducted in compliance with the committee's relevant guidelines and regulations. Written informed consent was obtained from all study respondents.

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Knowledge, attitudes and practices among human rabies surveillance professionals: cross-sectional study, Nghe An province, Viet Nam, 2025

PHAM Thi Cam Ha,[a] NGU Duy Nghia,[a] NGUYEN Thi Thanh Huong,[a] NGUYEN Hai Tuan,[a] NGUYEN Cong Khanh,[a] LE Hai Dang,[a] CHU Trong Trang,[b] NGUYEN Huy Anh,[b] TRAN Nhu Hai,[c] LE Do Muoi Thuong[d] and TRAN Nhu Duong[a]

Correspondence to Pham Thi Cam Ha (email: ptch@nihe.org.vn)

Objective: To evaluate knowledge, attitudes and practices (KAP) of health professionals regarding rabies surveillance in Nghe An province, Viet Nam, and identify associated factors.

Methods: A cross-sectional, descriptive and analytical study was conducted from 6 May to 30 June 2025. A structured questionnaire was distributed online to staff of preventive medicine, clinical and vaccination service units involved in rabies surveillance in Nghe An. For association analyses, KAP scores were categorized as adequate (≥70%) or inadequate (<70%). Descriptive statistics and logistic regression were performed.

Results: Overall, 29.2% (69/236) of respondents had inadequate knowledge scores, 5.1% (12/236) had inadequate attitude scores and 35.2% (83/236) had inadequate practice scores. Among preventive medicine staff, major gaps included 80.6% (79/98) reporting that they did not share bite-victim data with veterinary services and 60.2% (59/98) reporting that they did not use data-analysis tools. Altogether, 77.3% (85/110) of district-level staff and 78.5% (51/65) of private-facility staff were rated as having adequate knowledge compared with 50% (28/56) of commune-level staff. Having received training in the past 12 months was strongly associated with adequate practices (OR: 5.09, 95% CI: 2.86–9.05). In the adjusted model, adequate practices were associated with training in the past 12 months (aOR: 3.27, 95% CI: 1.46–7.34), district/provincial-level work (aOR: 3.16, 95% CI: 1.26–7.90), working at a private facility (aOR: 7.86, 95% CI: 1.98–31.24) and bachelor's level or higher education (aOR: 2.29, 95% CI: 1.02–5.14).

Discussion: Substantial gaps in surveillance-specific knowledge and practices were observed among surveillance professionals in Nghe An, particularly in preventive medicine and commune-level settings. Targeted training, routine use of data-analysis tools and stronger intersectoral data-sharing in line with existing national regulations are urgently needed to support Viet Nam's goal of eliminating dog-mediated human rabies deaths by 2030.

Human rabies remains a neglected zoonotic disease and a major public health concern in more than 150 countries. The disease causes an estimated 59 000 human deaths annually, predominantly in Asia and Africa where dog-mediated transmission accounts for more than 99% of cases.[1,2] Although safe and effective vaccines are available for human post-exposure prophylaxis (PEP) as well as animal vaccination, multiple barriers hinder progress towards elimination.[3] In Viet Nam, rabies is an endemic, notifiable disease requiring response and reporting within 48 hours.[4,5] During 2018–2024, Viet Nam recorded an annual average of approximately 80 human deaths and more than 600 000 people receiving PEP following dog bites (National Institute of Hygiene and Epidemiology, unpublished data, 2018–2024), resulting in a substantial economic burden. Nghe An, the largest province by land area in the northern region with a population exceeding 3.5 million, consistently reported the highest number of human rabies cases nationally during 2018–2024.[6,7] In

[a] National Institute of Hygiene and Epidemiology, Hanoi, Viet Nam.
[b] Nghe An Provincial Center for Disease Control and Prevention, Nghe An, Viet Nam.
[c] Institute of Population, Health and Development, Hanoi, Viet Nam.
[d] Danang Medical College, Danang, Viet Nam.
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response to high human rabies incidence and PEP use, provincial authorities launched a rabies control plan for 2022–2030 targeting zero human deaths by 2030.[8]

Viet Nam has national guidelines on human rabies surveillance and prevention, and general communicable disease regulations issued by the Ministry of Health. Strengthening surveillance is a central component of rabies control because it supports early detection of suspected cases, and encourages reporting within 48 hours, epidemiological investigation, identification of exposed persons, and coordination with veterinary authorities during outbreak investigation and response.[4,5,9]

Evidence from other rabies-endemic countries, such as Bangladesh, Ethiopia, Mozambique and Senegal, suggests that weaknesses in knowledge, attitudes and practices (KAP) among health professionals may hinder rabies prevention and surveillance.[10–13] In Viet Nam, an evaluation of rabies surveillance in southern provinces identified delayed reporting, challenges in assessing the timeliness and completeness of data, and limited use of surveillance data, but did not assess the KAP of front-line health workers responsible for implementing surveillance activities.[14] Upon a preliminary literature review, we found that there is a research gap in the area of health-care workers' KAP related to human rabies surveillance in Nghe An province and elsewhere in Viet Nam, particularly in the context of Viet Nam's National Rabies Control Programme 2022–2030 that aims to support the Global Strategic Plan to Eliminate Dog-Mediated Human Rabies by 2030.[15,16]

This study aimed to characterize the KAP of health-care professionals involved in human rabies surveillance in Nghe An province and to examine factors associated with adequate KAP.

METHODS

A cross-sectional study was conducted from 6 May to 30 June 2025 among health-care workers involved in human rabies surveillance in Nghe An province, Viet Nam.

Study population

The study population comprised health-care professionals directly engaged in rabies surveillance, classified by their role in rabies surveillance into three functional groups: (1) preventive medicine units (provincial Center for Disease Control and Prevention [CDC], district health centres, commune health stations); (2) clinical units (provincial and district hospitals); and (3) vaccination service units (public and private PEP providers).

Sample size was calculated using the single population proportion formula, assuming an estimated 71.4% proportion of professionals with adequate KAP based on a previous study,[17] a 95% confidence interval (CI) and 5% margin of error. The initial sample size was adjusted for the finite population of 654 professionals in Nghe An province and a 10% non-response rate was estimated, resulting in a minimum required sample size of 236 participants.

Convenience sampling was used. A list of units involved in human rabies surveillance or care in Nghe An province was compiled and professionals responsible for rabies surveillance, case management or reporting at each eligible unit were invited to participate. Participants came from Nghe An provincial CDC, four provincial hospitals, five private hospitals, all 20 district health centres, all seven district hospitals and all 79 private vaccination clinics. At the commune level, two communes were randomly selected per district. Each commune has one health station, and one professional responsible for rabies surveillance from each selected health station was invited to participate. In Viet Nam's administrative system at the time of data collection, before the administrative reorganization implemented in July 2025, districts were intermediate administrative units between the provincial and commune levels, while communes were the lowest administrative level, where commune health stations provide primary health care and participate in routine surveillance.

Data collection

Structured questionnaires were developed based on the *Guidelines for assessing nutrition-related knowledge, attitudes and practices* from the United Nations Food and Agriculture Organization (FAO) and the World Health Organization's *Communicable disease surveillance and response systems: guide to monitoring and evaluating*.[18,19] Items were mapped to the core surveillance functions specified in Viet Nam's national guidelines for the surveillance and prevention of rabies in humans.[4,19] All participants responded to the

sections on demographics/professional characteristics (6 questions), knowledge (13 multiple-choice questions) and attitudes (14 questions using a single 5-point Likert scale, 1 = strongly disagree to 5 = strongly agree, with higher scores indicating stronger agreement with the attitude statements). Questions about practices were role-specific and based on the responsibilities and core surveillance functions described in the national guidelines (preventive medicine: 13 questions; clinical: 8 questions; vaccination: 14 questions).[19] The questionnaire was reviewed by the research team and pre-tested with selected professionals from northern Viet Nam before the survey was implemented.

The questionnaire was administered online using Google Forms, and responses were collected anonymously. The first page provided information about the study's purpose, voluntary participation, anonymity and confidentiality; participants could stop at any time before submitting the form and were required to provide informed consent before accessing the questionnaire. A brief instructional video and the survey link were sent to all selected participants through Zalo, an instant messaging application commonly used in Viet Nam. The research team created a Google Sheet to monitor responses, established a Zalo messaging group for participants, and sent reminders to participants every 2 days until the end of data collection. Received survey data were stored in password-protected files accessible only to the study team.

Knowledge and practice scores were calculated as the number of correct responses divided by the total number of scored items for each respondent and expressed as percentages. Scores for attitudes were calculated as the sum of the 14 Likert-item scores divided by the maximum possible score of 70 and expressed as a percentage. KAP levels were categorized as poor (<70%), average (70–90%) or good (>90%), adapted from the FAO guidelines.[18]

Statistical analysis

Descriptive statistics were calculated (frequencies and percentages for categorical variables; mean and standard deviation for continuous variables). Age was categorized into four groups (<30, 30–39, 40–49 and ≥50 years) to allow comparisons across younger, middle-aged and older participants while maintaining sufficient numbers in each group. For association analyses, KAP scores were dichotomized as adequate (≥70%) or not adequate (<70%). Differences in KAP levels by sex, age group, education, work experience, workplace level and role in rabies surveillance were assessed using χ^2 tests. Because multiple bivariate comparisons were conducted, these analyses were considered exploratory; no formal adjustment for multiple testing was applied, and findings were interpreted with emphasis on effect sizes, CIs and consistency with multivariable models. Differences in group sizes were addressed by presenting both frequencies and percentages for each group and by using statistical tests appropriate for small expected counts. Multivariable analyses were performed using binary logistic regression to estimate crude and adjusted odds ratios (OR, aOR) with 95% CIs. Data were managed in Microsoft Excel and analysed using Stata version 17.0 (StataCorp LLC, College Station, Texas, United States of America).

RESULTS

Descriptive analysis

Study population

A total of 245 professionals in human rabies surveillance in Nghe An province were invited to complete the survey, of whom 236 responded (96.3%).

Sociodemographic characteristics

Females comprised 157 (66.5%) participants. The mean age was 39.9 ± 8.7 years. The largest age group was 30–39 years (113, 47.9%), followed by 40–49 years (56, 23.7%). College/associate degrees were held by 112 (47.5%) and bachelor's degrees by 101 (42.8%). Experience in rabies surveillance of 1–5 years was reported by 116 (49.2%) and 6–10 years by 53 (22.5%) (**Table 1**).

Overall distribution of KAP levels

Overall, 69 (29.2%) respondents were assessed as having poor knowledge, 135 (57.2%) as having average knowledge and 32 (13.6%) as having good knowledge (**Table 2**). Rabies knowledge was most comprehensive for transmission routes (100% of participants responded correctly), etiological agent (233, 98.7% correct) and

Table 1. **Demographic characteristics of human rabies surveillance professionals, Nghe An, Viet Nam, 2025 (*N* = 236)**

Variable	*n*	%
Age, years		
<30	21	8.9
30–39	113	47.9
40–49	56	23.7
≥50	46	19.5
Sex		
Male	79	33.5
Female	157	66.5
Education		
High school	3	1.3
College/associate degree	112	47.5
Bachelor's degree	101	42.8
Postgraduate (Master's/PhD)	20	8.5
Experience in rabies surveillance, years		
<1	20	8.5
1–5	116	49.2
6–10	53	22.5
11–15	29	12.3
>15	18	7.6
Workplace level		
Provincial	5	2.1
District	110	46.6
Commune	56	23.7
Private health care	65	27.5
Role in rabies surveillance		
Preventive medicine	98	41.5
Clinical	45	19.1
Vaccination service	93	39.4

main sources in Viet Nam (227, 96.2% correct). The largest knowledge gaps were in understanding of the outbreak definition (79, 33.5% correct), early outbreak detection activities (114, 48.3% correct) and the specimens used for laboratory confirmation (122, 51.7% correct) (**Table 3**).

Overall attitude scores are shown in **Table 2**. In item-level results, agreement with attitude statements were generally high. The largest proportions of participants agreed or strongly agreed that training courses improve the quality of rabies surveillance and control (227, 96.2%) and raising community awareness is crucial for rabies prevention and control (225, 95.3%), and they expressed willingness to participate in rabies outbreak response when needed (225, 95.3%). The lowest-scoring item was whether the current surveillance system was simple and feasible at the respondent's level, with 188 (79.7%) agreeing or strongly agreeing (**Table 3**).

Reported practices revealed major operational weaknesses, as shown by the overall score distribution in **Table 2** and selected item-level findings in **Table 3**. Among 98 preventive medicine staff, the largest gaps were not sharing bite-victim information with veterinary authorities (79, 80.6%) and not using data-analysis tools (59, 60.2%). Among 45 clinical staff, 20 (44.4%) responded correctly to the question on signs or symptoms used to

Table 2. **Distribution of human rabies surveillance professionals' knowledge, attitude and practice scores by level (poor, average, good)[a] and role in rabies surveillance, Nghe An, Viet Nam, 2025 (N = 236)**

Category and role	Poor (<70%)	Average (70–90%)	Good (>90%)
Knowledge	**69 (29.2)**	**135 (57.2)**	**32 (13.6)**
Preventive medicine (n = 98)	35 (35.7)	48 (49.0)	15 (15.3)
Clinical (n = 45)	15 (33.3)	27 (60.0)	3 (6.7)
Vaccination service (n = 93)	19 (20.4)	60 (64.5)	14 (15.1)
Attitudes[b]	**12 (5.1)**	**125 (53.0)**	**99 (41.9)**
Preventive medicine (n = 98)	4 (4.1)	43 (43.9)	51 (52.0)
Clinical (n = 45)	4 (8.9)	20 (44.4)	21 (46.7)
Vaccination service (n = 93)	4 (4.3)	62 (66.7)	27 (29.0)
Practices	**83 (35.2)**	**122 (51.7)**	**31 (13.1)**
Preventive medicine (n = 98)	51 (52.0)	47 (48.0)	0 (0.0)
Clinical (n = 45)	15 (33.3)	27 (60.0)	3 (6.7)
Vaccination service (n = 93)	17 (18.3)	48 (51.6)	28 (30.1)

Values are n (%).

[a] The thresholds for knowledge, attitude and practice levels are based on the Food and Agriculture Organization's 2014 guidelines for assessing nutrition-related knowledge, attitudes and practices.[18]

[b] For attitudes, "poor," "average" and "good" refer to total attitude scores of <70%, 70–90% and >90% of the maximum possible Likert score, respectively; higher scores indicate stronger agreement with statements supportive of rabies surveillance.

suspect rabies, and 37 (82.2%) correctly identified the information that should be recorded when documenting a suspected rabies case (**Supplementary Table 1**). Among 93 vaccination service staff, only 20 (21.5%) correctly answered the question on management of cases bitten by animals with clinical rabies (**Table 3**).

Bivariate analysis

Bivariate analysis revealed significant associations between adequate knowledge and both work experience (P = 0.021) and administrative level of the workplace (P = 0.001). By duration of work experience, adequate knowledge was observed in 12/20 (60.0%) respondents with <1 year of experience, 86/116 (74.1%) with 1–5 years, 40/53 (75.5%) with 6–10 years, 22/29 (75.9%) with 11–15 years and 7/18 (38.9%) with >15 years. By workplace level, adequate knowledge was observed in 3/5 (60.0%) provincial-level staff, 85/110 (77.3%) district-level staff, 28/56 (50.0%) commune-level staff and 51/65 (78.5%) private-facility staff (**Table 4**).

No statistically significant association was observed between age group and adequate knowledge, attitudes or practices. Adequate practices were associated with workplace level (P < 0.001). By workplace level, adequate practices were observed in 5/5 (100%) provincial-level staff, 74/110 (67.3%) district-level staff, 19/56 (33.9%) commune-level staff and 55/65 (84.6%) private-facility staff. No significant associations were observed between attitude scores ≥70% and sex, age, work experience, education or workplace (all P > 0.05) (**Table 4**).

Multivariate analysis

Factors associated with KAP outcomes were assessed by logistic regression (**Table 5**). For knowledge, workplace level was identified as the only independent predictor: compared with commune-level staff, the adjusted odds of adequate knowledge were higher among district/provincial-level staff (aOR: 5.78, 95% CI: 2.18–15.35; P < 0.001) and private-facility staff (aOR: 4.58, 95% CI: 1.19–17.56; P = 0.026). Other covariates were not significantly associated with adequate knowledge (P > 0.05) (**Table 5**).

A multivariable model for attitudes was not fitted because only 12 participants had attitude scores <70%, and some age groups had no participants with attitude scores <70%, resulting in sparse cells and quasi-complete separation (**Table 5**).

Table 3. **Selected item-level knowledge, attitude and practice findings among human rabies surveillance professionals by role in rabies surveillance, Nghe An, Viet Nam, 2025 (*N* = 236)**

Category and item		Surveillance role[a]			Total (*N* = 236)
Knowledge[a]		**Preventive medicine (*n* = 98)**	**Clinical (*n* = 45)**	**Vaccination service (*n* = 93)**	
What is the etiological agent of rabies?	Correct	95 (96.9)	45 (100.0)	93 (100.0)	233 (98.7)
	Incorrect	3 (3.1)	0 (0.0)	0 (0.0)	3 (1.3)
What is the most common source of human rabies in Viet Nam?	Correct	93 (94.9)	44 (97.8)	90 (96.8)	227 (96.2)
	Incorrect	5 (5.1)	1 (2.2)	3 (3.2)	9 (3.8)
What is the primary route of rabies transmission to humans?	Correct	98 (100.0)	45 (100.0)	93 (100.0)	236 (100.0)
	Incorrect	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Which specimen is used for laboratory confirmation of human rabies?	Correct	52 (53.1)	22 (48.9)	48 (51.6)	122 (51.7)
	Incorrect	46 (46.9)	23 (51.1)	45 (48.4)	114 (48.3)
How is a rabies outbreak defined?	Correct	29 (29.6)	15 (33.3)	35 (37.6)	79 (33.5)
	Incorrect	69 (70.4)	30 (66.7)	58 (62.4)	157 (66.5)
When should early outbreak detection activities be initiated?	Correct	48 (49.0)	17 (37.8)	49 (52.7)	114 (48.3)
	Incorrect	50 (51.0)	28 (62.2)	44 (47.3)	122 (51.7)
Attitudes					
The current surveillance system is simple and feasible at my level.	Strongly disagree	4 (4.1)	3 (6.7)	1 (1.1)	8 (3.4)
	Disagree	7 (7.1)	1 (2.2)	2 (2.2)	10 (4.2)
	Neutral	12 (12.2)	6 (13.3)	12 (12.9)	30 (12.7)
	Agree	34 (34.7)	21 (46.7)	42 (45.2)	97 (41.1)
	Strongly agree	41 (41.8)	14 (31.1)	36 (38.7)	91 (38.6)
I am willing to participate in rabies outbreak response when needed.	Strongly disagree	4 (4.1)	3 (6.7)	2 (2.2)	9 (3.8)
	Disagree	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Neutral	0 (0.0)	2 (4.4)	0 (0.0)	2 (0.9)
	Agree	31 (31.6)	18 (40.0)	32 (34.4)	81 (34.3)
	Strongly agree	63 (64.3)	22 (48.9)	59 (63.4)	144 (61.0)
Training courses improve the quality of rabies surveillance and control.	Strongly disagree	4 (4.1)	2 (4.4)	2 (2.2)	8 (3.4)
	Disagree	0 (0.0)	1 (2.2)	0 (0.0)	1 (0.4)
	Neutral	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Agree	24 (24.5)	14 (31.1)	21 (22.6)	59 (25.0)
	Strongly agree	70 (71.4)	28 (62.2)	70 (75.3)	168 (71.2)
Raising community awareness is crucial for rabies prevention and control.	Strongly disagree	4 (4.1)	4 (8.9)	2 (2.2)	10 (4.2)
	Disagree	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Neutral	0 (0.0)	0 (0.0)	1 (1.1)	1 (0.4)
	Agree	18 (18.4)	13 (28.9)	17 (18.3)	48 (20.3)
	Strongly agree	76 (77.6)	28 (62.2)	73 (78.5)	177 (75.0)
Practices[a]					
Do you share information on bite victims who go for rabies vaccination with veterinary authorities?[b]	Correct	19 (19.4)			19 (19.4)
	Incorrect	79 (80.6)			79 (80.6)
Do you use any tool to analyse data?[b]	Correct	39 (39.8)			39 (39.8)
	Incorrect	59 (60.2)			59 (60.2)

When suspecting a rabies case, which signs or symptoms do you rely on for diagnosis?[b]	Correct	20 (44.4)		20 (44.4)
	Incorrect	25 (55.6)		25 (55.6)
How do you manage cases bitten by animals with clinical rabies?[b]	Correct		20 (21.5)	20 (21.5)
	Incorrect		73 (78.5)	73 (78.5)

Values are *n* (%). Blank cells indicate that an item was not applicable to that professional group.

[a] For knowledge and practice items, responses were categorized as correct or incorrect according to the scoring key based on the national rabies surveillance guidelines; some practice items were originally yes/no questions.

[b] The denominator is the number of respondents in the applicable professional group, rather than the total number of professionals.

For practices, strong crude associations were observed for training in the past 12 months (OR: 5.09, 95% CI: 2.86–9.05; $P < 0.001$) and workplace level: compared with commune-level staff, the crude odds of adequate practices were higher among district/provincial-level staff (OR: 4.27, 95% CI: 2.17–8.43; $P < 0.001$) and private-facility staff (OR: 10.71, 95% CI: 4.48–25.61; $P < 0.001$). After adjustment, adequate practices were independently associated with training in the past 12 months (aOR: 3.27, 95% CI: 1.46–7.34; $P = 0.004$), district/provincial-level work (aOR: 3.16, 95% CI: 1.26–7.90; $P = 0.014$), working at a private facility (aOR: 7.86, 95% CI: 1.98–31.24; $P = 0.003$) and bachelor's-level or higher education (aOR: 2.29, 95% CI: 1.02–5.14; $P = 0.045$). Sex was retained in the model as an adjustment variable. Age group was not independently associated with adequate practices (**Table 5**).

DISCUSSION

This study identified important areas for capacity-strengthening in human rabies surveillance among health-care workers in Nghe An province, Viet Nam. Although agreement was generally high with statements that measured attitude, surveillance-specific knowledge and practices varied by professional role and health system level. Preventive medicine staff and commune-level staff showed the greatest need for support. Comparable patterns have been documented in other studies in rabies-endemic areas such as Bangladesh, Ethiopia and Senegal.[10–12] These findings indicated the need to strengthen practical surveillance capacity among professionals across endemic low- and middle-income countries.

These results also highlighted important weaknesses in core surveillance activities that are less often described in KAP studies. Most preventive medicine staff did not share information about bite-victims with veterinary authorities and did not use data-analysis tools; fewer than half of clinical staff correctly answered the item about the signs and symptoms used to suspect rabies; and a large majority of vaccination staff incorrectly managed bites from clinically rabid animals. Similar operational problems have been reported in human rabies surveillance in southern Viet Nam[14] in a study that documented delayed reporting, incomplete specimen collection and limited use of data for decision-making, and in Senegal[12] and Mozambique,[13] where poor notification procedures and weak collaboration between human and animal health sectors were noted. Taken together, these findings suggest that surveillance performance is influenced not only by individual KAP, but also by limitations in surveillance procedures, data systems and intersectoral coordination – key challenges for implementing a One Health approach. Sharing information on animal-bite victims with the veterinary sector is consistent with Viet Nam's regulatory framework for zoonotic disease prevention and control. The national interministerial circular on coordination for zoonotic disease prevention and control requires the health and agriculture sectors to coordinate in surveillance, outbreak investigation, response and communication for zoonotic diseases.[20] The national guideline for surveillance and prevention of rabies in humans also specifies that preventive medicine centres should coordinate with veterinary authorities when multiple people in the same locality seek rabies vaccination after animal bites, when a suspected human rabies case is clinically diagnosed or when a confirmed human rabies death occurs.[4] In this context, sharing bite-victim information can support tracing and assessment of biting animals, identification of high-risk locations, timely veterinary investigation and coordinated outbreak response. The low level of reported data-sharing observed in our study therefore reflects an important gap at the human–animal health interface.

Table 4. Association between knowledge, attitudes and practices (≥70% vs <70%) and demographic characteristics among human rabies surveillance professionals, Nghe An, Viet Nam, 2025 (***N*** = 236)

Variable	Knowledge			Attitudes			Practices		
	n (%) <70%	*n* (%) ≥70%	*P*[a]	*n* (%) <70%	*n* (%) ≥70%	*P*[a]	*n* (%) <70%	*n* (%) ≥70%	*P*[a]
Sex									
Female	40 (25.5)	117 (74.5)		8 (5.1)	149 (94.9)		62 (39.5)	95 (60.5)	
Male	29 (36.7)	50 (63.3)	0.073	4 (5.1)	75 (94.9)	1.000	21 (26.6)	58 (73.4)	0.050
Age group, years									
<30	4 (19.0)	17 (81.0)		0 (0.0)	21 (100.0)		7 (33.3)	14 (66.7)	
30–39	33 (29.2)	80 (70.8)	0.747	8 (7.1)	105 (92.9)	0.165	33 (29.2)	80 (70.8)	0.251
40–49	18 (32.1)	38 (67.9)		4 (7.1)	52 (92.9)		23 (41.1)	33 (58.9)	
≥50	14 (30.4)	32 (69.6)		0 (0.0)	46 (100.0)		20 (43.5)	26 (56.5)	
Work experience, years									
<1	8 (40.0)	12 (60.0)		1 (5.0)	19 (95.0)		10 (50.0)	10 (50.0)	
1–5	30 (25.9)	86 (74.1)		6 (5.2)	110 (94.8)		43 (37.1)	73 (62.9)	
6–10	13 (24.5)	40 (75.5)	0.021	1 (1.9)	52 (98.1)	0.442	15 (28.3)	38 (71.7)	0.485
11–15	7 (24.1)	22 (75.9)		2 (6.9)	27 (93.1)		9 (31.0)	20 (69.0)	
>15	11 (61.1)	7 (38.9)		2 (11.1)	16 (88.9)		6 (33.3)	12 (66.7)	
Education									
High school	1 (33.3)	2 (66.7)		0 (0.0)	3 (100.0)		2 (66.7)	1 (33.3)	
College/associate's degree	29 (25.9)	83 (74.1)		5 (4.5)	107 (95.5)		46 (41.1)	66 (58.9)	
Bachelor's degree	34 (33.7)	67 (66.3)	0.600	7 (6.9)	94 (93.1)	0.658	31 (30.7)	70 (69.3)	0.103
Postgraduate	5 (25.0)	15 (75.0)		0 (0.0)	20 (100.0)		4 (20.0)	16 (80.0)	
Workplace level									
Provincial	2 (40.0)	3 (60.0)		0 (0.0)	5 (100.0)		0 (0.0)	5 (100.0)	
District	25 (22.7)	85 (77.3)	0.001	5 (4.5)	105 (95.5)	0.802	36 (32.7)	74 (67.3)	<0.001
Commune	28 (50.0)	28 (50.0)		4 (7.1)	52 (92.9)		37 (66.1)	19 (33.9)	
Private facility	14 (21.5)	51 (78.5)		3 (4.6)	62 (95.4)		10 (15.4)	55 (84.6)	

[a] Fisher's exact test or Fisher–Freeman–Halton exact test, as appropriate.

This study identified marked differences in rabies surveillance performance by workplace level. Adequate knowledge was significantly more common among professionals working at district/provincial and private facilities than at the commune level, suggesting that access to guidance, supervision and routine exposure to bite management may be stronger in these settings. The lack of predictors for attitudes may be explained partly by the limited variability in attitude scores, as only 12 respondents had scores below 70%. Practices were most strongly associated with training in the past 12 months and workplace level, indicating that operational competencies may depend on opportunities to apply surveillance procedures in routine work, refresher training and supportive supervision. However, some adjusted estimates, particularly for private-facility work, had wide CIs, suggesting statistical imprecision that may reflect the small numbers in some subgroups. These associations should, therefore, be interpreted cautiously. The association between sex and adequate practices in the adjusted model should also be interpreted cautiously, as it may reflect differences in task allocation, training opportunities or supervisory support. Overall, the findings suggest that surveillance gaps are driven not only by individual capacity but also by system-level differences across facility tiers, consistent with One Health implementation challenges in endemic settings.

Table 5. **Multivariate analysis of factors associated with adequate knowledge and practices among human rabies surveillance professionals, Nghe An, Viet Nam, 2025 (*N* = 236)**

Outcome	Predictor	Crude odds ratio (95% CI)	*P*	Adjusted odds ratio[a] (95% CI)	*P*
Knowledge ≥70%	Male vs female	0.59 (0.33–1.05)	0.075	0.75 (0.37–1.52)	0.430
	Clinical vs preventive medicine	1.11 (0.53–2.34)	0.782	0.52 (0.19–1.42)	0.200
	Vaccination vs preventive medicine	2.16 (1.13–4.15)	0.020	0.96 (0.29–3.13)	0.945
	Training in the past 12 months (yes vs no)	1.55 (0.88–2.74)	0.129	0.79 (0.36–1.72)	0.547
	Age 30–39 vs <30 years	0.57 (0.18–1.82)	0.344	0.67 (0.19–2.44)	0.546
	Age 40–49 vs <30 years	0.50 (0.15–1.69)	0.263	0.69 (0.16–2.96)	0.622
	Age ≥50 vs <30 years	0.54 (0.15–1.89)	0.334	1.11 (0.24–5.06)	0.898
	Experience (≥5 years vs <5 years)	0.67 (0.38–1.20)	0.177	0.80 (0.39–1.65)	0.544
	Education (≥Bachelor's degree vs <Bachelor's degree)	0.74 (0.42–1.30)	0.300	0.63 (0.29–1.36)	0.238
	Workplace level (district/province vs commune)	3.26 (1.65–6.42)	<0.001	5.78 (2.18–15.35)	<0.001
	Workplace level (private vs commune)	3.64 (1.65–8.03)	0.001	4.58 (1.19–17.56)	0.026
Practices ≥70%	Male vs female	1.80 (1.00–3.26)	0.051	2.38 (1.09–5.21)	0.030
	Clinical vs preventive medicine	2.17 (1.04–4.53)	0.039	0.67 (0.24–1.84)	0.433
	Vaccination vs preventive medicine	4.85 (2.51–9.37)	<0.001	1.13 (0.36–3.56)	0.837
	Training in the past 12 months (yes vs no)	5.09 (2.86–9.05)	<0.001	3.27 (1.46–7.34)	0.004
	Age 30–39 vs <30 years	1.21 (0.45–3.27)	0.704	1.19 (0.33–4.28)	0.785
	Age 40–49 vs <30 years	0.72 (0.25–2.05)	0.536	0.91 (0.22–3.85)	0.902
	Age ≥50 vs <30 years	0.65 (0.22–1.91)	0.434	0.66 (0.14–3.07)	0.596
	Experience (≥5 vs <5 years)	1.17 (0.68–2.00)	0.570	2.12 (0.97–4.64)	0.060
	Education (≥Bachelor's degree vs <Bachelor's degree)	1.76 (1.03–3.02)	0.040	2.29 (1.02–5.14)	0.045
	Workplace level (district/province vs commune)	4.27 (2.17–8.43)	<0.001	3.16 (1.26–7.90)	0.014
	Workplace level (private vs commune)	10.71 (4.48–25.61)	<0.001	7.86 (1.98–31.24)	0.003

CI: confidence interval.

[a] Adjusted for sex, role in rabies surveillance, training in the past 12 months, age group, experience, education and workplace level.

Strengths of the study include comprehensive coverage of core surveillance functions across preventive medicine, clinical and vaccination units at multiple health system levels, which have been rarely achieved in previous KAP surveys. Moreover, the alignment of the questionnaire with national guidelines supports assessment of competencies relevant to the national rabies surveillance system.

This study has several important limitations. First, although it was designed from a One Health perspective, we could not survey the animal-health sector. During the study period, the veterinary system in Viet Nam was undergoing administrative reform, with changes to district and commune animal-health units and staffing. As a result, the study was unable to assess KAP among veterinary officers, which limits its ability to describe the full human–animal interface of rabies surveillance. Second, because of the cross-sectional design, the study could identify associations but could not determine causal relationships or underlying reasons for observed practices. Third, data were collected through an online self-administered questionnaire, which may have introduced selection bias related to internet access or digital literacy, recall bias and social desirability bias. Because responses were anonymous, the characteristics of respondents and non-respondents could not be compared; however, the response rate was high (96.3%), which may have reduced the potential for non-response bias. Some respondents may have over-reported desirable behaviours, such as timely reporting or correct PEP practices, and reported practices could not be independently verified. Fourth, data were collected from a single province using convenience sampling, so the results may not fully represent rabies surveillance professionals in Viet Nam. Despite these limitations, the study provides evidence that important gaps exist in both knowledge and practices related to human rabies surveillance, and its quality is strengthened by the grouping of professionals by role and health system level and by the use of a structured, guideline-based KAP assessment instrument.

In conclusion, substantial gaps in surveillance-specific knowledge and, especially, practices persist among front-line human rabies surveillance professionals in Nghe An, particularly in preventive medicine and commune-level settings. These gaps may hinder One Health collaboration and undermine efforts to prevent human rabies deaths despite the preventive tools available. Targeted interventions are needed, especially practical, guideline-based training; simplified digital reporting and data-analysis tools; routine intersectoral information-sharing; and regular feedback on human–animal interface data. Qualitative research to elucidate barriers, and intervention studies to improve the surveillance system, are logical next steps. Strengthening surveillance capacity is essential to meeting the global 2030 target of zero dog-mediated human rabies deaths.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

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Investigation of a measles outbreak on Phu Quoc Island, Viet Nam, April–June 2024

Pham Nguyen Phu Khanh,[a] Tran The Vinh,[a] Vo Thi Thuy Tram,[a] Bui Trung Nghia,[a] Le Hoang Phuong[a] and Nguyen Ngoc Bao Chau[a]

Correspondence to Pham Nguyen Phu Khanh (email: phamkhanh3897@gmail.com)

Objective: In 2024, following detection of a measles outbreak on Phu Quoc Island, Viet Nam, an investigation was conducted to describe the epidemiological characteristics and assess response timeliness using the 7-1-7 framework.

Methods: Suspected measles cases were identified through syndromic surveillance (those with fever and rash, plus respiratory inflammation and/or conjunctivitis) and confirmed by serological testing. Demographic and epidemiological information was collected with standardized questionnaires. Vaccination status was verified using the National Immunization Information System and personal vaccination records, with full vaccination defined as two doses of measles-containing vaccine. The 7-1-7 framework was used to assess timeliness of detection (7 days), notification (1 day) and response (7 days).

Results: Of 137 suspected measles cases occurring between 7 April and 7 June 2024, 83 (60.6%) were confirmed. Cases occurred mainly among school-aged children (6–10 years, $n = 55$; 40.1%), with schools as the primary exposure setting ($n = 56$; 40.9%). Among the 55 school-aged children, 10 (18.2%) were fully vaccinated. The attack rate was significantly higher among school-aged children who had not received two vaccine doses than among those who were fully vaccinated (0.9% [45/4988] vs 0.1% [10/8917], $P < 0.001$). Outbreak detection was delayed by 15 days, notification occurred within 1 day of identification of the first suspected case, and response was within 5 days of notification.

Discussion: This outbreak was likely caused by gaps in vaccination coverage and delayed recognition of early warning signs. Strengthening immunization, early case detection and reporting systems are essential to prevent future outbreaks.

Measles is an infectious disease caused by a virus that spreads easily through the air when an infected person coughs or sneezes.[1] The disease can lead to serious complications, especially in children younger than 5 years, including pneumonia, encephalitis, ear infections and diarrhoea.[2] Despite effective vaccines, measles remains a major global health problem, accounting for an estimated 10.3 million cases and 107 500 deaths in 2023.[3] Reduced vaccination coverage during the COVID-19 pandemic has contributed to rising measles cases and outbreaks worldwide.[3]

The most effective way to prevent measles is to ensure that children receive two doses of a measles-containing vaccine (MCV). These two doses, usually given as the measles–mumps–rubella vaccine, provide about 97% protection.[2] To prevent outbreaks, the World Health Organization recommends that coverage with two doses should reach at least 95% in every community.[3] In Viet Nam, the measles vaccine has been part of the Expanded Program on Immunization since the mid-1980s, with the first dose (MCV1) given at 9 months of age and the second dose (MCV2) added to routine vaccinations in 2006 and now administered at 18 months of age.[4] Viet Nam maintained strong measles control for many years, but disruptions during the COVID-19 pandemic caused declines in the coverage of routine vaccinations and created immunity gaps during 2021–2022.[5] These gaps have contributed to the resurgence of measles in several areas.

Phu Quoc, Viet Nam's largest island, lies off the coast of An Giang Province in the southwest, covers about 574 km^2 and has a population of more than 150 000 people. As a major tourism and commercial hub, the island welcomed around 5.4 million visitors in 2023. As no confirmed measles cases had been reported in Phu Quoc since the most recent increase in measles cases during 2019–2020, measles was considered

[a] An Giang Provincial Center for Disease Control, An Giang, Viet Nam.
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non-endemic on the island. On 22 April 2024, the An Giang Provincial Center for Disease Control (CDC) recorded a suspected measles case in Phu Quoc, with an elementary school identified as the starting point of the outbreak. This investigation was conducted to describe the characteristics of the outbreak and to evaluate early response actions.

METHODS

A field investigation team of five members, including epidemiologists, clinicians and laboratory staff from the An Giang Provincial CDC, investigated the measles outbreak. The investigation was carried out on Phu Quoc Island from 22 April to 7 June 2024.

Case definitions

This investigation used two case definitions for measles, in accordance with the guidelines of Viet Nam's Ministry of Health.[6] A suspected clinical measles case was defined as a person presenting with fever and rash between 17 March and 7 June 2024, with at least one of the following symptoms: cough, runny nose or conjunctivitis. A laboratory-confirmed measles case was defined as a suspected case who had a positive measles immunoglobulin M (IgM) test result.

Case finding

Records at the Phu Quoc Health Centre were reviewed to identify cases, and additional case finding was conducted in the community. An active syndromic surveillance system was established to detect cases at the health centre, at private clinics and in the community.

Data collection

A standardized questionnaire (**Supplementary Material**) was used to collect demographic, clinical and epidemiological information. To identify the likely exposure setting, patients were asked about contact with individuals who met the suspected measles case definition. Data were collected through interviews with patients, or with caregivers for those younger than 15 years.

Vaccination status was verified using the National Immunization Information System and personal vaccination records. MCV coverage on Phu Quoc Island was estimated using population data from a random survey of 240 children younger than 10 years across eight of the island's nine communes (30 children per commune).

Sample collection and laboratory analysis

A 3-mL blood sample was collected from each suspected case. The serum was extracted, stored at the Provincial CDC and transported to the Pasteur Institute in Ho Chi Minh City within 3 days of collection. Measles IgM antibodies were detected using enzyme-linked immunosorbent assay.

Data analysis

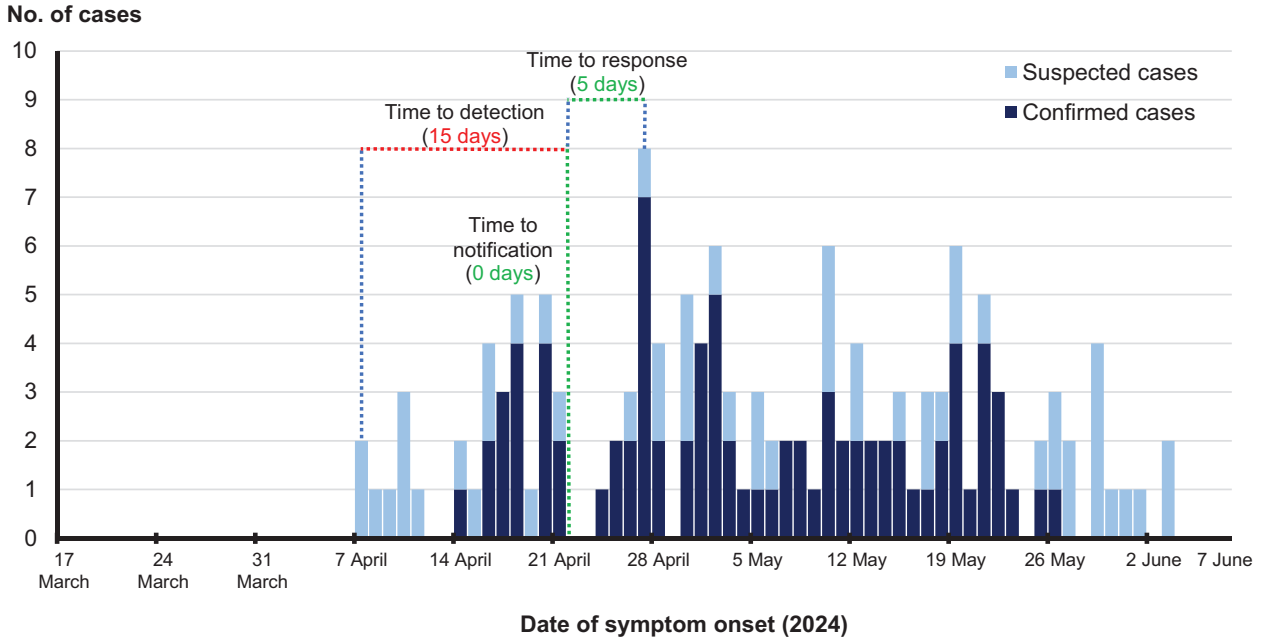
Frequencies and percentages of case characteristics, as well as attack rates overall and by age group, were calculated in Microsoft Excel. Differences in attack rates between undervaccinated and fully vaccinated groups were assessed using Pearson's X^2 test in Open Source Epidemiologic Statistics for Public Health (OpenEpi) software version 3.01.[7] Three age groups (<2, 2–5 and 6–10 years) were selected for attack rate analysis, as they had the highest number of cases and corresponded to the target population for a planned supplementary measles vaccination campaign (1–10 years).

Assessment of outbreak response timeliness

The 7-1-7 Assessment Tool[8] was used to evaluate the timeliness of outbreak detection, notification and response, and to identify bottlenecks and enabling factors for performance improvement. The framework defines targets for detection within 7 days of emergence, notification within 1 day of detection and initiation of response actions within 7 days of notification.

Viet Nam's Ministry of Health defines an outbreak of measles as three epidemiologically linked cases, at least two of whom are laboratory-confirmed. For the purposes of the 7-1-7 assessment, the date of emergence is defined as the symptom onset date of the earliest epidemiologically linked case.

Fig. 1. **Epidemic curve of 137 suspected and laboratory-confirmed measles cases, Phu Quoc Island, Viet Nam, April–June 2024**



RESULTS

Epidemiological characteristics

In total, 137 suspected cases of measles were identified in seven out of nine communes on Phu Quoc Island from 7 April to 7 June 2024. From these cases, 83 blood specimens (60.6%) were collected, and all tested positive for IgM antibodies against measles. The overall incidence of measles was 77 cases/100 000 population. No deaths were reported.

Fig. 1 shows the epidemic curve of the measles outbreak. The earliest case developed symptoms on 7 April. The daily number of cases increased quickly from mid-April and peaked on 27 April at eight cases. The number of cases then gradually declined, with new cases reported until early June.

The first detected case was a 9-month-old female who developed symptoms on 20 April and presented to the provincial obstetric and paediatric hospital on 22 April. The hospital notified the Provincial CDC of the suspected measles case on the same day, and the case was subsequently laboratory-confirmed for measles. The investigation retrospectively identified two earlier suspected cases with symptom onset on 7 April at the same primary school: a 10-year-old household contact of the first detected case and one of her classmates. The household contact had presented to the health centre on the day of symptom onset but was not suspected with measles at the time. No specimens were collected from these two cases, and their sources of infection could not be determined. Another student from the same primary school, with symptom onset around the same time as the first detected case, was also laboratory-confirmed for measles. These four epidemiologically linked cases, of which two were laboratory-confirmed, met the national definition of a measles outbreak.

Table 1 describes the characteristics of the measles cases. Cases were evenly distributed between males and females. Most cases occurred in school-aged children, especially those aged 6–10 years (55/137, 40.1%). Schools were the main exposure setting (56, 40.9%), with additional exposures in health centres (18, 13.2%). More than half of the cases were hospitalized (78, 56.9%). A total of 75 cases (54.7%) had an unknown vaccination history, and 33 (24.1%) were unvaccinated. Seventeen cases (12.4%) had received one dose of an MCV, and 12 (8.8%) had been fully vaccinated.

A community survey on the island found that 52.5% of children had received two doses of MCV, 20.7% had

Table 1. **Characteristics of measles cases and measles attack rates by age group and vaccination status, Phu Quoc Island, Viet Nam, April–June 2024 (*N* = 137)**

Characteristic	No.	%	Population	Attack rate (%)
Sex				
Male	69	51.4	–	
Female	68	48.6	–	
Age group (years)				
<2	**26**	**19.0**	**506**	**5.1**
Undervaccinated	25	18.2	455	5.5
Fully vaccinated	1	0.8	51	2.0
2–5[a]	**36**	**26.3**	**5927**	**0.6**
Undervaccinated	35	25.5	2918	1.2
Fully vaccinated	1	0.8	3009	0.03
6–10[a]	**55**	**40.1**	**13 905**	**0.4**
Undervaccinated	45	32.8	4988	0.9
Fully vaccinated	10	7.2	8917	0.1
11–16[b]	**15**	**10.9**	**–**	
>16[b]	**5**	**3.6**	**–**	
Exposure setting				
School	56	40.9	–	
Community	25	18.2	–	
Health centre	18	13.2	–	
Unknown	38	27.7	–	
Vaccination status				
Unknown	75	54.7	–	
Unvaccinated	33	24.1	–	
1 dose	17	12.4	–	
≥2 doses	12	8.8	–	

[a] Differences in attack rates between undervaccinated and fully vaccinated groups were statistically significant ($P < 0.001$) based on Pearson's X^2 test.

[b] Age groups 11–16 years and >16 years were not included in the analysis of attack rates by vaccination status because the analysis focused on children aged 1–10 years, who accounted for most cases and were the target population for the planned supplementary measles vaccination campaign.

received one dose, and 26.8% were unvaccinated or had unknown vaccination status.

Attack rate

Table 1 shows the measles attack rate by age group and vaccination status. Children younger than 2 years had the highest attack rate (5.1%, 26/506), compared to 0.6% (36/5927) in children 2–5 years and 0.4% (55/13 905) in children 6–10 years. In all age groups, attack rates were higher among undervaccinated children than among fully vaccinated children. Differences between undervaccinated and fully vaccinated children were statistically significant in the 2–5 and 6–10-year age groups ($P < 0.001$).

Public health response

The outbreak was detected late, with a 15-day delay from symptom onset of the earliest case to identification. Notification was timely: it was completed on the same day. Outbreak response measures were fully implemented within 5 days of notification, meeting the 7-1-7 response target (**Fig. 1**).

The investigation and response team was deployed within 1 day of notification (23 April 2024). Risk communication and coordination were established on the same day. Specimens from the first detected case were collected on 22 April, and laboratory confirmation was obtained on 25 April, a turnaround time of 3 days. Public health response measures were implemented between 22 and 25 April, within 3 days. These included distribution of soap, disinfectants and personal protective equipment to communities, schools and health-care facilities, and strengthening MCV availability through the Expanded Programme on Immunization for children aged 9 months to 2 years. Mask use was mandated in schools, and cases were isolated either in health-care facilities or at home, depending on severity. The most time-consuming activity was the epidemiological analysis and initial risk assessment, which required 5 days, from 22 to 27 April. Overall, core response actions were completed within 7 days, meeting the 7-1-7 response target.

Several bottlenecks were identified during the response to the outbreak through the 7-1-7 assessment, review of investigation records and discussions with response team members. These included: (1) limited training of health professionals in surveillance and response, (2) low clinical suspicion among health workers, (3) a lack of coordination across public health units or agencies, and (4) access issues at several exposure locations. Several enablers were also noted: (1) resources were available for response initiation and rapid resource mobilization, (2) laboratory capacity was adequate, and (3) follow-up was carried out in accordance with the initial risk assessment.

DISCUSSION

The measles outbreak on Phu Quoc Island was notable, as it occurred after more than 5 years without reported cases. Most cases had not been fully vaccinated, which facilitated virus transmission, or had an unknown vaccination status. Similar patterns were reported in United States of America in 2025,[9] where 96% of cases were unvaccinated or had unknown vaccination status, and in other countries, including Pakistan in 2017,[10] Botswana in 2023[11] and Bosnia and Herzegovina in 2024.[12] Due to the high transmissibility of measles, at least 95% vaccination coverage is needed to prevent outbreaks,[2] and failure to achieve this level likely contributed to this outbreak.

The age distribution showed that measles risk was not limited to the youngest children, consistent with other outbreaks.[10–12] Measles is very contagious, affecting people of any age who are not vaccinated, highlighting the need to reduce the risk of measles in people of all ages, not only children younger than 5 years. Strengthening routine immunization and implementing supplementary immunization activities for children aged 1–10 years are essential to rapidly control outbreaks and prevent recurrences.

In this outbreak, the high number of hospitalized patients increased the burden on health-care resources. This pattern is consistent with reports from earlier measles epidemics, when hospitals saw a continual increase in hospitalizations of children who had pneumonia or needed special isolation.[13] Measles can cause severe illness, particularly in young, unvaccinated children,[13] and immunity gaps can strain health-care systems. High vaccination coverage and early detection of suspected cases are essential to reduce complications and limit pressure on health-care services.

During this outbreak, measles transmission occurred more frequently in schools than in the community or health-care facilities, consistent with findings from other countries.[14] Close contact among vulnerable children in schools facilitates transmission. This outbreak likely began in a primary school and spread to household contacts and the wider community. These findings highlight the importance of schools in early detection and the need for stronger collaboration between schools and health-care providers to promptly identify suspected cases and limit transmission.

The outbreak was detected late, with a 2-week gap between the first case's symptom onset and confirmation, indicating that the 7-1-7 detection target was not achieved. It was retrospectively found that 10 cases had presented to a health facility before the first detected case but were not accurately diagnosed at the time. Additionally, the cluster at the primary school was not initially reported to the local health station. These represent missed opportunities to have met the detection target. However, notification and responses were timely, with control measures implemented within a few days. Research analysing 41 responses to public health emergencies in Brazil, Ethiopia, Liberia, Nigeria and Uganda between 2018 and 2022 found that only 54% met the 7-day

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detection target.[15] This highlights the possibility that early cases may be unreported if medical professionals do not recognize them. This is consistent with previous research that discovered 61% of detection bottlenecks were in health-care facilities.[12] Delayed detection allows for undetected transmission and complicates outbreak control. Strengthening clinical suspicion, improving event-based surveillance and ensuring prompt reporting of suspected cases are essential to improve early detection and outbreak response.

This study had several limitations. Incomplete immunization data necessitated that vaccination coverage be estimated using survey and population data, which may have affected the accuracy of attack rate estimates. Limited clinical outcome data also restricted assessment of the full health burden. However, the use of standardized investigation forms based on national guidelines and comprehensive case identification from health-care facilities and communities strengthened the findings.

The 2024 measles outbreak on Phu Quoc Island, Viet Nam was likely caused by gaps in measles vaccination coverage and delays in recognizing early warning signs, which allowed for transmission before control measures were implemented. Strengthening routine immunization, improving early case detection and enhancing reporting systems are essential to prevent future outbreaks. Applying the results of the 7-1-7 evaluation can also help enhance the effectiveness of recognizing and responding to measles and other infectious diseases.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

This outbreak investigation was conducted as part of routine public health activities for infectious disease prevention and control at the local level. No personal or sensitive patient information was collected. The findings were used exclusively for outbreak detection and response; therefore, ethical review and approval by an institutional review board were not required.

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Preparation for introducing initial risk assessment into infectious disease surveillance in Indonesia: insights from a pilot implementation, 2024–2025

Shingo Nishiki,[a] Irma Gusmi Ratih,[b] Rizki Dinar Winiar,[a] Nur Assyifa Daiyah Fillah,[a] Eka Muhiriyah[b] and Triya Novita Dinihari[b]

Correspondence to Shingo Nishiki (email: snishiki@utopia.ocn.ne.jp)

Risk assessment (RA) is an integral component of overall risk management, serving as a systematic process for gathering, evaluating and documenting information to determine risk levels and guide evidence-based public health actions.[1,2] The International Health Regulations (2005) (IHR) require Member States to develop RA capacities at both national and subnational levels.[1,3] The 2023 World Health Organization (WHO) joint external evaluation of Indonesia's IHR core capacities acknowledged the country's capability to conduct rapid RAs (RRAs) for major public health events at the central level.[4] However, some challenges remain regarding regular RA activities, especially at the subnational level, partly due to the lack of a uniform RA framework. For example, RAs are not always conducted systematically because they are not standardized, often relying on an individual's skills and judgement. Thus, priorities may vary for disease and response actions, posing challenges to achieving a shared understanding of risk among stakeholders. Therefore, there is an expectation among stakeholders that initial RAs (IRAs) must be integrated into regular surveillance activities.

In 2024, representatives from the Indonesian Ministry of Health (MOH), in collaboration with the WHO Representative Office for Indonesia and the Japan International Cooperation Agency (JICA), initiated efforts to strengthen RA capacities at both national and subnational levels. Indonesia's RA guidelines integrate methodologies from three documents: existing standard operating procedures (SOPs) developed by the MOH's Public Health Emergency Operations Center (PHEOC) (Ministry of Health, unpublished documents, 2017 [in Indonesian]), the *Interim guide for using initial risk assessment algorithm, version 2.5* (WHO Regional Office for South-East Asia, unpublished guide, 2023), and WHO's guidelines for RRAs.[1] The operational workflow begins with the collection of signals from multiple sources, followed by their screening, selection and verification (triage) using criteria based on the SOPs and pertinent literature (**Fig. 1**).[5,6] Selected signals undergo an IRA using an algorithm outlined in the interim IRA guide, which incorporates questions across five domains: high-threat pathogens, exposure, severity, spread potential and capacity. Subsequently, the risk level is categorized into five grades – very low, low, moderate, high and very high – each accompanied by a level of confidence. The assessment is summarized in a predefined format. Based on the RA, recommended actions are implemented, and an RRA may be conducted. Lists of high-threat pathogens and corresponding actions have been contextualized for Indonesia. Core elements of WHO's interim IRA and RRA guidelines have been integrated into Indonesia's RA guidelines.

Additionally, supporting materials have been developed to facilitate IRA implementation. A fact sheet was developed to summarize the characteristics of 36 prioritized infectious diseases in Indonesia. This table is a quick reference tool, covering key epidemiological, clinical and preventive aspects of these diseases. It enables users to efficiently review essential information about each

[a] Project for Strengthening Capacity for Early Warning and Response to Infectious Diseases, Japan International Cooperation Agency, Jakarta, Indonesia.
[b] Directorate of Surveillance and Health Quarantine, Ministry of Health, Jakarta, Indonesia.
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Table 1. **Agenda of 2-day workshop on enhancing risk assessment capacity, Indonesia, September 2024**

Day	Time	Topic	Training method
Day 1	Morning	Pre-test	Online timed test
		Introduction to initial risk assessment	Lecture
		Utilization of supporting materials for initial risk assessment	Lecture
	Afternoon	Group exercise for initial risk assessment	• Small-group project • Presentation
		7-1-7 target[a] for early detection and response to infectious disease threats	Lecture
Day 2	Morning	Risk communication	Lecture
		Introduction to hazard calendar	Lecture
	Afternoon	Group exercise for hazard calendar	• Small-group project • Presentation
		Post-test	Online timed test

[a] 7-1-7 target: 7 days to detect, 1 day to notify, 7 days to respond.

disease. Two tutorial videos were developed detailing the RA process and the contents of the fact sheet, providing practical guidance on the conduct of an IRA through a scenario-based case study.

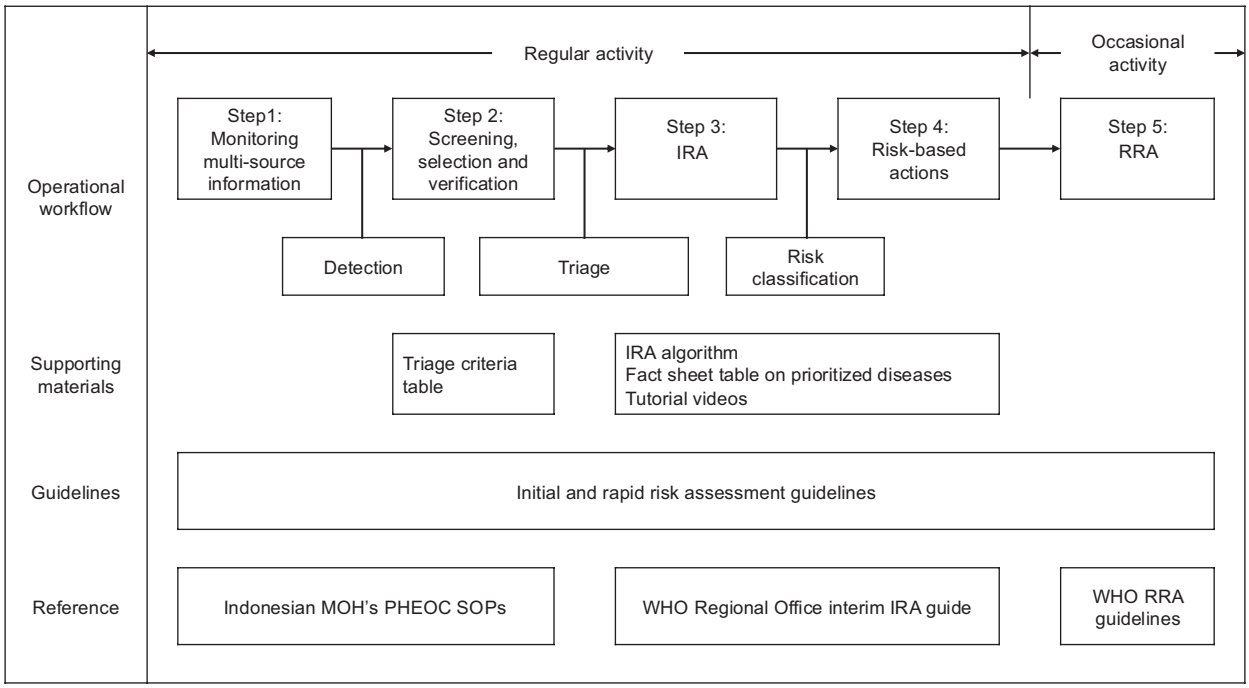
Workshops on implementing IRAs were conducted in combination with a hazard calendar activity that integrates data on diseases prone to outbreaks with information on potential natural hazards, enabling authorities to anticipate a wide range of threats.[7] These workshops were a collaborative effort among representatives of the Indonesian MOH, the WHO Representative Office for Indonesia and JICA to enhance all-hazard emergency prevention, preparedness and response. The first 2-day workshop took place in September 2024, involving over 20 participants from the Surveillance Unit, the PHEOC and other disease-specific programmes within the MOH (**Table 1**). The second workshop, held in January 2025, engaged 36 representatives from provincial and district health offices, focusing on piloting subnational implementation.

Participants attended lectures and completed practical exercises about IRAs and hazard calendars, along with additional sessions covering risk communication and the 7-1-7 evaluation framework.[8] During these exercises, participants conducted simulated IRAs and developed hazard calendars using real data from specific diseases. The second workshop's exercises were facilitated by representatives who had participated in the first workshop, exemplifying effective knowledge transfer and in-house capacity-building. Overall, the participants' understanding of RAs was enhanced through the subnational workshop, as demonstrated by an increase in average test scores from 53% (pre-test) to 81% (post-test).

Based on the results of the workshops, all materials were finalized, and both national and subnational guidelines were published in July 2025.[9] A new trial commenced in 2025 aimed at integrating IRAs into activities at both the central and subnational levels. Since then, PHEOC officers have regularly conducted IRAs in line with the workflow (**Fig. 1**) and, in cooperation with representatives from the WHO Representative Office for Indonesia, prepared summary documents in the predefined format. Some of the surveyed provincial and district health offices reported that they had incorporated IRA reports into their weekly bulletins. At both levels, IRA summaries are shared with relevant sectors across programmes and departments. It is planned to provide technical support from the national to provincial level and from the provincial to district level.

The introduction of the IRA received positive feedback from surveillance officers; for example, some officers reported that IRA tools enable them to conduct systematic analyses and assessments instead of relying on subjective individual skills. By following the algorithm, officers can collect focused information leading to in-depth analyses, precise risk estimates and evidence-based conclusions. As a result, clear guidance for further actions based on the assessed risk levels enhances the prioritization of responses and facilitates prompt, structured and targeted interventions. Additionally, the

Fig. 1. **Initial risk assessment surveillance operational workflow and relevant reference materials, Indonesia, 2024**



IRA: initial risk assessment; PHEOC: Public Health Emergency Operations Center; RRA: rapid risk assessment; SOP: standard operating procedure; WHO: World Health Organization.

IRA summaries help foster a common understanding of disease events among relevant stakeholders, promoting cross-sector coordination. Moreover, these documents would provide compelling data when advocating with decision-makers.

While integrating IRAs into routine surveillance operations can enhance response capacity, their implementation presented several main challenges. First, they impose an additional workload on surveillance officers. The organization of an IRA can be time-consuming and a burden on the resources of the implementers. Some health offices have begun addressing this by implementing IRAs on a trial basis, by adjusting the frequency of assessments or the number of events documented in IRA summaries or by focusing on events with higher potential impacts. Second, it may take time for implementers to adapt to cross-sector coordination. Some facilities have promoted awareness of IRAs and aligned risk perceptions among stakeholders by actively sharing information through group communication channels. Third, algorithm-based RAs may be new to subnational officers with less experience, posing technical difficulties. Although the flowchart is standardized and straightforward, conclusions regarding risk and levels of confidence vary among officers. IRAs require skills to manage uncertainty when there is insufficient information to reach conclusions. However, the effective use of supporting materials and the implementation of additional IRAs, combined with technical support and feedback, can facilitate officers' development and optimize IRA practices. Fourth, the establishment of an effective knowledge transfer scheme is essential for expanding capacity. Thus, it is vital to foster facilitators who promote horizontal knowledge transfer among subnational officers for long-term success. Lastly, the monitoring of responses to health emergencies is crucial for evaluating the initiative's impact. Improvements in participants' knowledge of RAs and constructive operational changes were observed during the workshops and in their subsequent activities. However, ongoing monitoring through evaluation schemes, such as the WHO-recommended 7-1-7 framework, is the next step in assessing practical enhancements.[8]

In summary, efforts to enhance RA capacity through piloting IRA implementation have commenced in Indonesia. The standardized and systematic assessment process will facilitate a risk-based approach that supports evidence-based decision-making and

proportionate public health responses. Moreover, it could contribute to regional capacity-building, providing practical insights and serving as a model for similar initiatives in other countries.

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The authors used ChatGPT-5 (OpenAI) to assist with language editing and proofreading to enhance the clarity of the manuscript. The authors verified all suggestions and take responsibility for the integrity of the final content.

Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

Formal ethical approval was not sought as research was not undertaken. Permission for project implementation and publication was obtained from the Indonesian MOH.

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Artificial intelligence and biosecurity in ASEAN: implications for surveillance and response

Yujin Xu,[a] Alvin Qijia Chua,[a] Mely Caballero-Anthony[a,b] and Li Yang Hsu[a,c]
Correspondence to Li Yang Hsu (email: mdchy@nus.edu.sg)

The rapid uptake of artificial intelligence (AI) in biomedical science research is enabling advances in bioinformatics, pathogen characterization, protein design and drug discovery in ways that were difficult to envision even 5 years ago. Nonetheless, these capabilities inherently have the potential to be misapplied to cause harm, and the pace of their evolution risks outpacing efforts at governance.[1]

In the near-to-medium term, AI tools may alter the biosecurity threat landscape in ways that directly challenge – but also facilitate – existing surveillance and response systems. Advances in protein design, for example, enable the rapid development and modification of biologically active molecules that may evade existing nucleic acid-based biosecurity screening tools.[2] As part of an international security conference, the drug development company Collaborations Pharmaceuticals, Inc. showed how AI could be used to generate over 40 000 highly toxic – including novel – molecules within hours by rewarding toxicity.[3] Although the novel molecules were *in silico* predictions that were neither synthesized nor validated, the process showed how AI tools could potentially be redirected towards harm.

Likewise, barriers to reconstructing and modifying known pathogens have also been lowered by the public availability of pathogen genetic sequences that can be coupled with AI-enabled design tools and accessible gene synthesis platforms.[1,2] As a silver lining, significant practical constraints remain, most notably access to materials as well as technical and laboratory capabilities, rendering the risk of misuse or accidental generation of high-consequence pathogens theoretical rather than imminent.

At present, most AI tools deployed in biomedical research lack embedded safeguards, including screening filters or output watermarking.[4] As the tools increasingly become part of laboratory workflows, they may introduce new vulnerabilities, particularly if pathogen inventory systems or synthetic biology platforms are involved.[1] Current biosecurity frameworks are mostly designed around physical containment and may not adequately address the risks in situations where life sciences, synthetic biology, AI and automation intersect.

National biosafety and biosecurity policy and legislation documents were reviewed for all Association of South-eastern Asian Nations (ASEAN) Member States that were available online as of 5 August 2026, including the Biological Weapons Convention implementation database and published literature; this pragmatic review is summarized in **Table 1**.[5–7]

Whereas most Member States have established biosafety frameworks aligned with the Cartagena Protocol on Biosafety,[8] many are largely focused on genetically modified organisms. Only Singapore (Biological Agents and Toxins Act; 2005) and Thailand (Pathogens and Animal Toxins Act; 2015) have comprehensive, dedicated biosecurity legislation. Others rely on sectoral regulations or non-binding guidelines that predate AI as a transformative research force. These governance and

[a] Asia Centre for Health Security, Saw Swee Hock School of Public Health, National University of Singapore, Singapore.
[b] Centre for Non-Traditional Security Studies, S. Rajaratnam School of International Studies, Nanyang Technological University, Singapore.
[c] Yong Loo Lin School of Medicine, National University of Singapore, Singapore.
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Table 1. **National biosafety and biosecurity legal frameworks in ASEAN Member States**[a]

Country	Biosafety legislation	Biosecurity or related legislation
Brunei Darussalam	• No primary biosafety law • National biosafety and biosecurity guideline and National Laboratory Strategic Plan 2026–2031 under development, with support from the Regional Public Health Laboratory Network	• Laws of Brunei Darussalam, Chapter 87, Biological Weapons (1983)
Cambodia	• Biosafety Act 2008 – superseded by the 2023 Environment and Natural Resources Code (Royal Kram NS/RKM/0623/007 of 29 June 2023) • National Medical Laboratory Biosafety Guidelines 2016	• Law on the Prohibition of Chemical, Nuclear, Biological and Radiological Weapons (2009) implements BWC obligations • Draft Prakas on laboratory biosafety/biosecurity (2017, not finalized) • No comprehensive legislation governing pathogen possession, handling and transfer
Indonesia	• Omnibus Health Law (Law No. 17 of 2023) • Indonesian National Standard 8340:2016 on Laboratory Biorisk Management • GMO biosafety regulations (Cartagena Protocol)	• Omnibus Health Law (Law No. 17 of 2023) repealed former Law No. 6 of 2018 on Health Quarantine • No dedicated pathogen possession/transfer legislation
Lao People's Democratic Republic	• National Biosafety Regulation 2019 • National Laboratory Quality Standard 2018	• National Biosafety Regulation 2019
Malaysia	• Biosafety Act 2007 (Act 678, GMO-focused) • Biosafety (Approval and Notification) Regulations 2010 • Laboratory Biosafety and Biosecurity Policy and Guideline 2015	• Strategic Trade Act 2010 (Act 708) • Prevention and Control of Infectious Diseases Act 1988 (Act 342)
Myanmar	• No primary biosafety legislation identified	• No primary biosecurity legislation identified • The Environmental Conservation Law (2012) includes provisions for hazardous substances, including "substance which may be used as a biological weapon"
Philippines	• Executive Order 514 (2006) on the National Biosafety Framework (GMO-focused) • 2023 Manual of Laboratory Biosafety and Biosecurity Standards (2nd edition)	• No primary biosecurity legislation identified • Section 4(d) Anti-Terrorism Act of 2020 prohibits the development, possession, export, supply and use of biological weapons when committed with a terrorist purpose • Strategic Trade Management Act 2015 covers export, import and transshipment of biological agents
Singapore	• Biological Agents and Toxins Act 2005 • Infectious Diseases Act • Singapore Standard ISO 35001:2021+A1:2024 biorisk management standard	• Biological Agents and Toxins Act 2005 also serves as primary biosecurity law for dangerous pathogens and toxins
Thailand	• Pathogens and Animal Toxins Act B.E. 2558 (2015) • GMO biosafety regulations under Cartagena Protocol	• Pathogens and Animal Toxins Act B.E. 2558 (2015) covers possession, production, import/export and transit
Timor-Leste	• Decree-Law No. 41/2023 on the General Regulation on Quarantine covers import/export controls on animals and animal products with biosafety provisions for animal disease prevention	• No primary biosecurity legislation identified • Penal Code Article 211 from Decree-Law No. 19/2009 prohibits biological weapons-related activities
Viet Nam	• Decree No. 103/2016/ND-CP Regulating Biosafety in Laboratories • Law on Biodiversity 2008 (Law No. 20/2008/QH12) • Decree 118/2020/ND-CP amended Decree 69/2010/ND-CP on Biosafety for GMOs and GMO products (G/SPS/N/VNM/175, 2025 on gene editing in progress)	• Law No. 114/2025/QH15 on Disease Prevention (2026)

ASEAN: Association of South-eastern Asian Nations; BWC: Biological and Toxin Weapons Convention; GMO: genetically modified organisms.

[a] Compiled from the BWC Implementation Database and national legislative sources.[5] All Member States are States Parties to the BWC.

regulatory gaps could affect ASEAN's capacity to detect, assess and respond to emerging biological threats, including those enabled by AI.

ASEAN's consensus-based governance model offers both strengths and constraints in shaping how the region might address these emerging risks.[9] The preference for non-binding declarations and frameworks accommodates diverse institutional capacity and encourages regional alignment, but the lack of enforcement has historically resulted in uneven implementation.[9]

The 2024 ASEAN Leaders' Declaration on Strengthening Regional Biosafety and Biosecurity was an important political commitment, recognizing the need for stronger national frameworks and regional commitment.[10] It has heightened policy attention and catalysed the establishment of the ASEAN Network on Biosafety and Biosecurity with international support.[10,11] However, the Declaration does not address AI-related biosecurity risks, and these have not been incorporated into existing surveillance and response systems, as recommended by the World Health Organization (WHO) publication Asia Pacific health security action framework (APHSAF).[12]

Without deliberate integration of biosafety, biosecurity and AI policies and regulations, there is a real risk that future AI biosecurity initiatives – policy, governance and other measures to prevent the misuse or creation of AI tools that can facilitate the development or deployment of harmful biological agents – might evolve parallel to, rather than in alignment with, existing frameworks and surveillance and response systems. Whether from deliberate misuse or accidental release, AI-enabled biological risks – hazards whose probability or impact are materially increased by AI – may manifest as public health events within the scope of national outbreak and APHSAF operational frameworks. Recommended initiatives for AI biosecurity in ASEAN Member States are summarized in **Box 1** and described in detail below.

The ASEAN Network provides a potential platform for future dialogue, technical leadership and cooperation, as well as for the incorporation of AI biosecurity into national and regional health security systems. To prevent fragmentation and inefficiency, other ASEAN platforms, such as the ASEAN Centre for Public Health Emergencies and Emerging Diseases (ACPHEED), should also play complementary roles.

Supplementary protocols addressing AI in the biomedical sciences that are aligned with existing international biosafety and biosecurity guidelines, such as WHO's *Laboratory biosecurity guidance*, should be developed by the Network in collaboration with ACPHEED and other international partners.[13] These protocols should include guidance for governance and policy, in addition to technical guidance for AI-enabled laboratory systems and predeployment risk assessments of biological design models, especially for high-consequence material.

Box 1. Recommended initiatives for AI biosecurity in ASEAN member states

- Integrate biosafety, biosecurity and AI policy and regulation so that AI biosecurity aligns with existing frameworks and surveillance and response systems, rather than being developed in parallel.
- The ASEAN Network on Biosafety and Biosecurity should lead the development of policies and frameworks to embed AI biosecurity in national and regional health security systems; to avoid fragmentation, other platforms should be involved, such as ACPHEED.
- Establish an incident-reporting mechanism for AI-related biosecurity events via the Network and ACPHEED, linked to International Health Regulations (2005) event-based surveillance, so that novel risks are detected and reported early.
- Invest in regional capacity to complement the 2024 ASEAN Leaders' Declaration on Strengthening Regional Biosafety and Biosecurity.[10]
- Develop supplementary AI protocols aligned with the World Health Organization's *Laboratory biosecurity guidance*, covering governance and policies, technical guidance for AI-enabled laboratory systems, and predeployment risk assessments.[13]
- Engage AI developers as partners with shared responsibilities, and ensure that adherence to AI biosecurity standards is a condition of procurement and deployment.

ACPHEED: ASEAN Centre for Public Health Emergencies and Emerging Diseases; AI: artificial intelligence; ASEAN: Association of Southeast Asian Nations.

The responsibility for biosecurity should be shared by global authorities and the developers of AI tools, in accordance with emerging international consensus, such as the Asilomar principles for governing AI applications in nuclear and biological security.[1] In particular, AI developers must bear a special responsibility for anticipating biological risks that may arise from rapid commercial innovation,[1] including through red-teaming (i.e. deliberately testing AI systems for vulnerabilities or ways they could be misused to facilitate biological harms) and perhaps implementing clear reporting and notification mechanisms that enable suspected misuse attempts to be identified and reported to appropriate national authorities. ASEAN Member States should make adherence to these responsibilities a condition of procurement or deployment.

Sustained investment in regional capacity development on AI biosafety and biosecurity that complements the existing commitment within the Declaration will be necessary.[10] A reporting mechanism and monitoring for AI-related biosecurity incidents could be established by the Network and implemented by ACPHEED alongside existing International Health Regulations (2005) event-based surveillance systems, increasing the likelihood that novel AI-related risks are detected early rather than remaining outside existing reporting structures.

Finally, predeployment biosecurity reviews should be mandated for AI models identified to have significant dual-use potential, especially for those to be deployed within biomedical laboratory settings. These review processes should operate at the national level, focus on misuse potential and downstream risk, and involve regional coordination and expertise running through the Network, if needed.

In conclusion, the growing convergence of AI and biomedical research is inevitable and largely beneficial. However, this potentially accelerates and expands the challenges of mitigating dual-use scenarios. Building on the Declaration and establishment of the Network, ASEAN can close the gaps identified here, adding AI biosecurity within and strengthening existing national and regional surveillance and response systems in preparation for the emerging AI era, while contributing to wider international efforts.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

Ethics approval was not required for this work. This Perspective draws on a review of publicly available legislation, official policy documents and published literature, and did not involve human participants, identifiable personal data or animal subjects.

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Risk assessment of cholera outbreaks in Eastern Visayas, Philippines, 2024

Soonjong Bae,[a] Boyd Roderick Cerro,[b] Angelito Umali,[c] Lalaine Villasis,[d] Kathleen Ryan,[a] Bonifacio Magtibay,[a] Albert John Enrico Dominguez,[a] Harriette Linelle Cruz,[a] Andrea Gail Palagbas,[d] Rez Dacoco,[b] Percival De Paz,[b] Ludina L Insigne,[b] Marvin Jed C Soledad,[b] Jody Nesus,[b] Nayco Yap,[c] Eleanor Salvador-Peña,[c] Katherine Gamiao,[c] Ian Christian Gonzales[d] and Yui Sekitani[a]

Correspondence to Soonjong Bae (email: beasunjong@gmail.com)

Objective: This study presents the findings of a joint cholera risk assessment conducted in Eastern Visayas, the region in the Philippines with the highest incidence of the disease in 2022–2023. The study aimed to identify key risk factors, review progress since a 2016 assessment, and highlight persistent gaps in prevention, preparedness and response.

Methods: In July 2024, the World Health Organization, the United Nations Children's Fund and the Philippine Department of Health conducted a joint assessment using a standardized checklist for focus group discussions and interviews across four technical areas: partnership and coordination; epidemiology and surveillance; water, sanitation and hygiene (WASH); and risk communication and community engagement. Epidemiological trends between 2022 and 2024 were analysed, and water samples from wells and refilling stations were tested for *Escherichia coli* and total coliforms.

Results: From 2022 to 2024, 12 284 cholera cases were reported in Eastern Visayas (case fatality rate: 0.5%). Testing showed 100% contamination in Level I and II sources, while 33% of Level III samples tested positive for total coliforms despite no *E. coli* detection. Partial progress has been made in implementing the 2016 assessment's recommendations, with good practices in surveillance, water sampling and community awareness, although gaps remain in outbreak response, coordination and WASH access.

Discussion: This assessment identified both progress and persistent challenges across the four technical areas. Key limitations were found in the qualitative design and the limited geographical coverage. Conclusions focused on prioritizing the strengthening of national cholera strategies by embedding them within the broader Food and Waterborne Diseases Prevention and Control Program alongside local ownership and equity-focused WASH investments.

Cholera is a highly transmissible disease spread through contaminated food or water, and can cause death within hours.[1,2] Cholera outbreaks continue to affect populations with limited access to sanitation, particularly in developing countries and regions affected by poverty, displacement, conflict and climate change.[3,4]

Despite global efforts to reduce the spread of disease, transmission persists, with 472 697 cases reported to the World Health Organization (WHO) in 2022 and 535 321 in 2023.[5] The true burden is expected to be much greater, with 1.3–4 million estimated cases and 21 000–143 000 deaths annually.[6]

In 2023, the Philippines reported 3982 cholera cases and 19 deaths to WHO.[5] The Eastern Visayas region recorded the highest incidence among all 17 regions in both 2022 and 2023 (Department of Health, Philippines, Epidemic-prone Disease Case Surveillance [EDCS] report, morbidity weeks 52, 2022, and 48, 2023, respectively. Unpublished data). The region has a history of significant outbreaks of cholera and acute watery diarrhoea (AWD); in June 2016, Samar Province declared an AWD outbreak, with 1573 cases and 32 deaths.[7] In response, fellows from the Department of Health (DOH) Field Epidemiology Training Program conducted epidemiological investigations,[8] while WHO

[a] World Health Organization Representative Office for the Philippines, Manila, Philippines.
[b] Center for Health Development Eastern Visayas, Eastern Visayas, Philippines.
[c] United Nations Children's Fund, Manila, Philippines.
[d] Epidemiology Bureau, Department of Health, Manila, Philippines.
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Table 1. **Recommendations from the 2016 cholera risk assessment and 2024 assessment of their implementation, by domain**

2016 recommendation	2024 implementation level	Progress notes
Partnership and coordination		
Strengthen coordination and partnerships within the EOC for effective outbreak response.	Partially implemented	While the EOC has been established as a central command hub, further improvements are needed to clarify its operational role through the development of comprehensive TOR and SOPs.
Establish the EOC as a central command hub and create comprehensive TOR and SOPs to clarify its operational role.		
Establish regular Incident Command System meetings to reinforce the EOC's function as a multidisciplinary centre for consolidating and documenting information from various sources.	Partially implemented	While Incident Command System meetings have been conducted to reinforce the EOC's function as a multidisciplinary centre, further improvements are needed to consolidate and document information from various sources.
Conduct regular multisectoral coordination meetings, involving the surveillance and epidemiology, WASH and RCCE clusters to ensure coordinated actions, information sharing, and the regular dissemination of situation reports to maintain robust partnerships and support collective response efforts.	Partially implemented	While multisectoral cluster meetings involving surveillance and epidemiology, WASH and RCCE are conducted as part of the cholera response, they are not systematically convened for all events.
Relocate the EOC to a flood-free area optimized for communication, with fully operational equipment.	Not implemented	Formal planning for relocation and equipment upgrading has not been initiated.
Epidemiology and surveillance		
Enhance case-based reporting by integrating a suspected case definition for AWD as a notifiable condition within the Philippine Integrated Diseases Surveillance and Response system.	Partially implemented	Although AWD is included in the case definition for suspected cholera, which is a notifiable disease, AWD itself has not yet been designated as a notifiable condition.
Reclassify cholera as a Category 1 notifiable condition, requiring reporting within 24 hours.	Not implemented	There have been no formal administrative discussions or policy reviews initiated regarding the reclassification of the disease status.
Implement comprehensive risk assessment and outbreak response training at all administrative levels, with an emphasis on timely, adaptable local risk assessments.	Not implemented	While general outbreak response trainings have been conducted, specific capacity building for timely and adaptable local risk assessments has not yet been implemented.
Enhance event-based surveillance at all levels and develop a risk matrix to prioritize high-risk villages for focused interventions.	Partially implemented	While event-based surveillance has been enhanced at all levels, the development of a risk matrix to prioritize high-risk villages for focused interventions has not yet been implemented.
WASH		
Improve supply systems to reduce contamination, promote household water treatment and safe storage, and establish regular water quality monitoring in high-risk areas.	Partially implemented	Training on water safety planning was initiated in 2016–2017 in collaboration with partners and remains an ongoing requirement for water districts.
Advise the public to avoid water sources that test positive for *Escherichia coli*, along with addressing water supply issues in health-care facilities.	Partially implemented	WASH communication began in 2016, and the implementation of the WASH FIT plan in the region is underway. Additionally, municipal health offices in selected provinces have been trained in the application of WASH FIT with support from UNICEF.
Maintain clean drinking-water containers, expand access to toilets and handwashing facilities, and implement solid waste management in schools through collaboration with the Department of Education.	Partially implemented	The implementation of the Department of Education's WinS Program Three-Star Approach in Eastern Visayas has been supported through capacity-building and technical assistance provided by UNICEF, in collaboration with the National WinS Technical Working Group. From school year 2017–2018 to 2023–2024, the proportion of public schools in the region with at least a one-star rating increased significantly, from 2% to 61% (representing schools achieving at least a one-star rating out of the total schools participating in the national WinS monitoring).[a]

2016 recommendation	2024 implementation level	Progress notes
Update and disseminate best practices from the Philippine Approach to Sustainable Sanitation program, launched by UNICEF post-Typhoon Haiyan.	Partially implemented	The Philippine Approach to Sustainable Sanitation training and programmatic support were provided to Samar and Northern Samar provinces, enabling them to achieve more than 12 municipalities and multiple villages with zero open defecation. Additionally, orientation on the Approach for other provinces in Eastern Visayas was conducted in collaboration with the National Economic and Development Authority – Eastern Visayas and the Regional Development Council.
Establish Local Drinking-water Quality Monitoring Committees and enhance data management systems for WASH activities.	Partially implemented	Several local government units have established their committees, with capacity-building efforts planned for implementation. In Eastern Visayas, local drinking-water quality monitoring committees have also been set up with support from UNICEF.
RCCE		
Reinforce messages on safe water practices and expand information access through media.	Fully implemented	WHO, in collaboration with DOH, produced a 30-second commercial on safe water the previous year.
Monitor and evaluate communication activities, enhancing DOH staff capacity in risk communication.	Partially implemented	RCCE trainings have been conducted, but only at the staff level; plans for senior-level training are currently underway. Staff-level personnel include health promotion officers, nurses and other implementers responsible for carrying out health promotion and RCCE initiatives at the local level. Senior-level officials, on the other hand, serve as decision-makers and institutional spokespersons, including regional directors and assistant regional directors.
Provide targeted training for managers and senior staff.	Partially implemented	The DOH Health Promotion Bureau, in collaboration with USAID and WHO, has conducted national and subnational capacity-building activities for RCCE in health emergencies. In 2023, the DOH and WHO jointly organized a training on crisis communication and infodemic management training. The workshop was attended by managerial and senior staff from various centres for health development, including regional directors and assistant regional directors. However, a training specifically dedicated to managers and senior officials has yet to be conducted.
Promote exclusive breastfeeding to prevent diarrhoea, and educate water vendors on maintaining water quality at refilling stations, with regular monitoring by local government units.	Not implemented	DOH has implemented breastfeeding campaigns; however, they are not explicitly linked to diarrhoeal disease prevention.
Carry out ongoing IEC campaigns across communities, schools and health-care facilities to promote basic hygiene and sanitation practices.	Fully implemented	The DOH Central Office successfully cascaded IEC materials to the subnational level. Regional offices were provided with budgets to produce these materials and disseminate them in various settings, including schools and communities. During the field visits, IEC materials were observed to be visibly displayed in these locations.
Teach the community how to prepare homemade oral rehydration solution.	Partially implemented	DOH has produced IEC materials, including videos, on how to prepare oral rehydration solution. However, based on interviews with some village health workers, there is a continued need for dedicated community education, as some community members still lack knowledge and skills on oral rehydration solution preparation.

AWD: acute watery diarrhoea; DOH: Department of Health; EOC: emergency operations centre; IEC: information, education and communication; RCCE: risk communication and community engagement; SOPs: standard operating procedures; TOR: terms of reference; UNICEF: United Nations Children's Fund; USAID: United States Agency for International Development; WASH: water, sanitation and hygiene; WASH-FIT: Water and Sanitation for Health Facility Improvement Tool; WHO: World Health Organization; WinS: Water, Sanitation and Hygiene in Schools.

[a] Department of Education, Philippines; 2024.[9]

Source: 2016 cholera risk assessment. Manila: World Health Organization/Department of Health, Philippines; 2016. Unpublished internal report.

and DOH conducted a joint risk assessment that resulted in the 2016 recommendations evaluated in this study (**Table 1**).

In January 2024, the DOH Eastern Visayas Center for Health Development (EVCHD) requested a new cholera risk assessment from WHO following outbreaks in 2022 and 2023. A joint mission was conducted in July 2024 by WHO, the United Nations Children's Fund (UNICEF), the DOH Epidemiology Bureau and EVCHD. Three primary risk questions guided this assessment: What factors sustain cholera transmission in Eastern Visayas, what progress has been made, and which gaps have remained across key technical areas since 2016?

METHODS

Site selection

EVCHD identified cities and municipalities for the risk assessment based on whether any confirmed cholera case or cholera outbreak had been recorded since 1 January 2022.

Risk assessment team

A total of 18 members participated in the mission, including six from WHO, four from UNICEF and eight from EVCHD. They were divided into two teams, each comprising technical focal points for surveillance and epidemiology; water, sanitation and hygiene (WASH); and risk communication and community engagement (RCCE). Teams were supported by local focal persons from the assessment sites.

Risk assessment procedures

The assessment was conducted from 8 July (day 0) to 12 July 2024 (day 4). On day 0, teams convened with EVCHD leadership to finalize the methodology. The assessment applied an operational multisectoral approach.

On 9–10 July, assessments were conducted in separate geographical areas, with team 1 in Eastern Samar and team 2 in Samar, followed by a joint assessment in the City of Tacloban in Leyte on 11 July (**Fig. 1**).

A standardized risk assessment checklist was developed by the teams and systematically applied across all technical areas (**Supplementary Materials 1–3**). Qualitative data were collected through focus group discussions and interviews that sought representation from all relevant technical categories, including municipal health officers, village health workers, sanitary inspectors, disease surveillance officers and other health providers, as well as community members. Data were collected in English, Filipino, and the local dialects Visayan and Waray. These procedures applied to all technical areas, including RCCE. Information about partnerships and coordination was captured through cross-cutting items embedded within the checklists.

Water sampling and testing

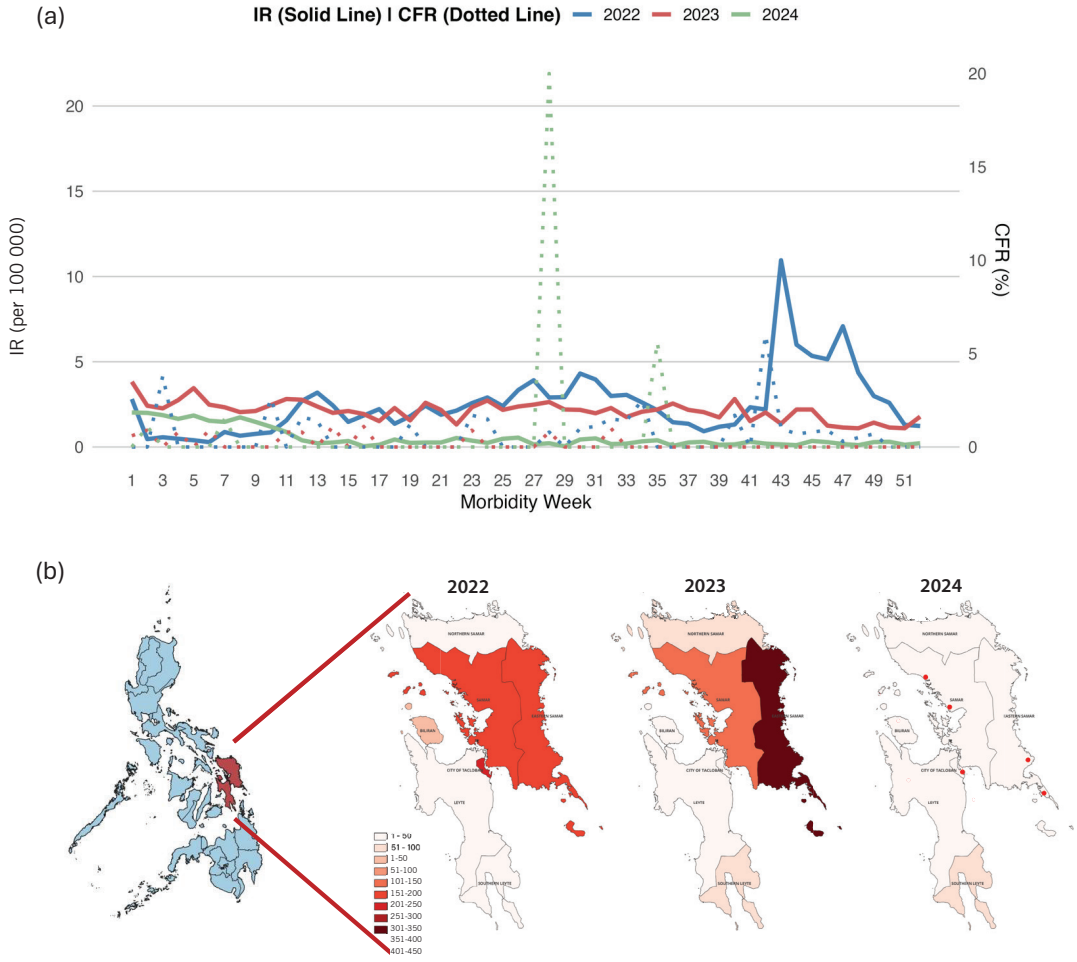
To assess water source contamination at the assessment sites, environmental sampling was conducted. Using purposive sampling, a total of 19 water samples were collected from Level I, II and III water sites reported to have high cholera incidence. In the Philippines, Level I refers to sources such as protected wells or developed springs without distribution systems; Level II consists of communal faucet systems connected to a piped distribution network; and Level III is a waterworks system that provides piped connections directly to households.[10] All samples were analysed using Colilert-18 (IDEXX, Westbrook, ME, USA) enzyme-substrate water testing kits to determine the presence of total coliform and *Escherichia coli*, following the Philippine National Standards for Drinking-water of 2017[11] and standard methods for water and wastewater testing.[12]

Samples were collected from drinking-water sources, storage facilities and distribution lines following DOH standard procedures. They were processed within a maximum holding time of 6 hours after collection and then placed in portable incubators at 35 °C for 18 hours. The results were interpreted based on colour changes: colourless (negative), yellow (positive for total coliforms) and yellow with fluorescence under ultraviolet light (positive for *E. coli*) using Colilert-18 and ColiKat (ColiKat, Seoul, Republic of Korea) systems.[13]

Epidemiological data and case definitions

A descriptive analysis was conducted to assess epidemiological trends from 2022 to 2024 using an EVCHD Regional Epidemiology and Surveillance Unit (RESU) line list, which included all suspected, probable and confirmed cholera cases and deaths.

Fig. 1. **Trends in cholera incidence/100 000 population and CFR by: (a) morbidity week; and (b) spatial distribution of incidence,[a] Eastern Visayas, Philippines, 2022–2024**



CFR: case fatality rate; IR: incidence rate.

[a] The red dots on the 2024 map indicate the locations of risk assessment areas.

Case definitions followed national surveillance frameworks, and these changed over time. Between 2008 and 2021, a suspected case was a person aged ≥5 years presenting with AWD, and a confirmed case required laboratory confirmation of *Vibrio cholerae* O1 or O139.[14]

In 2022, definitions transitioned to the EDCS guidelines, which required that a case be aged ≥2 years and have signs of severe dehydration in addition to AWD. Then, during the large outbreaks from February 2022 to March 2024, a broader definition was temporarily adopted to support the response: a suspected case was defined as anyone aged ≥2 years with AWD but without the requirement for severe dehydration; a probable case was a suspected case with a positive result from a rapid diagnostic test (RDT); and a confirmed case required laboratory confirmation.[15] After case numbers declined in March 2024, the region reverted to the EDCS definition of cases in non-endemic areas, which required severe dehydration.

Data analysis and visualization

To characterize the outbreak, weekly aggregated cases, deaths, spatial distribution maps and case fatality rates (CFRs) were calculated for each morbidity week. The annual incidence was estimated using population denominators derived from the 2023 Philippine Statistical Yearbook based on 2020 census projections.[16]

All identifiable data were anonymized in line with ethical standards. Spatial analysis was conducted in QGIS open-source software v. 3.40 (https://qgis.org), and all other analyses were done in RStudio 2024.04.2+764 (R Core Team, Vienna, Austria; https://www.r-project.org/about.html).

To assess implementation of the 2016 recommendations, findings from the 2024 assessment were systematically compared with each recommendation and grouped into four technical areas: partnership and coordination, epidemiology and surveillance, WASH and RCCE. Implementation status was categorized as "not implemented", "partially implemented" or "fully implemented", with accompanying narrative notes (**Table 1**).

Synthesis of findings and reporting

On 11 July 2024, technical teams consolidated their findings and formulated recommendations. On 12 July, key summary findings and recommendations were presented to the EVCHD regional director and other stakeholders.

RESULTS

Cholera epidemiology

Between 2022 and 2024, Eastern Visayas reported a total of 12 284 cholera cases, with 5959 cases in 2022, 5029 in 2023 and 1296 in 2024. Altogether, 60 deaths occurred over this period (44 in 2022, 11 in 2023, 5 in 2024), yielding an overall CFR of 0.5%. Samar recorded the highest cumulative burden over the 3 years (4457 cases; 33 deaths; CFR: 0.7%), followed by Eastern Samar (3454 cases; 4 deaths; CFR: 0.1%) and Leyte (1513 cases; 12 deaths; CFR: 0.8%).

The annual cholera incidence for 2022–2024 showed Eastern Samar in 2023 with the highest incidence (410/100 000 population), followed by the City of Tacloban in 2022 (345) and Samar in 2022 (296) (**Fig. 1**).

Review of 2016 recommendations

Of the 20 recommendations from the 2016 assessment, only two were fully implemented, both of which were in the RCCE category. While most other recommendations across all categories were partially implemented, including all five WASH-related actions, key areas in partnership and epidemiology still face implementation gaps (**Table 1**).

Partnership and coordination

The 2024 risk assessment indicated that the Emergency Operations Center (EOC) had yet to assume a fully functional coordination role during outbreaks. Terms of reference and standard operating procedures remained incomplete, limiting its operational capacity. Incident Command System meetings occurred but lacked sufficient multidisciplinary engagement, preventing the EOC from fully serving as a central command hub.

Significant variation was observed in local government unit (LGU) engagement in cholera and WASH-related activities and in outbreak response mechanisms. In the Philippines, while DOH can recommend outbreak declarations at the LGU level based on epidemiological criteria, declaration authority rests with the local chief executives. This can cause the two levels to have different counts of epidemiological and declared outbreaks.

Progress in strengthening partnerships was noted through recent collaboration between the Department of the Interior and Local Government, the Philippine Information Agency and the Department of Social Welfare and Development. Informants highlighted the fact that the 2022 cholera outbreak in Samar had demonstrated improved collaboration, as local officials worked closely with health workers, and multisectoral teams were convened for joint investigations, comprising health, surveillance, laboratory, sanitation inspectors, and Food and Waterborne Diseases Prevention and Control Program staff.

Governance challenges hindered the implementation of WASH initiatives. Although Local Drinking-water Quality Monitoring Committees are mandated, many remained inactive or lacked clearly defined roles. WASH staffing shortages persisted, with sanitation inspectors overseeing populations above the recommended ratio of 1:20 000,[17] leading to heavy workloads and high turnover. A good practice identified in Samar involved village sanitation inspectors receiving modest honoraria from municipal budgets. Additionally, LGUs had not fully used available funding streams, such as for disaster risk reduction and management, to strengthen WASH programmes.

Epidemiology and surveillance

Weekly case-based reporting to the Philippine Integrated Disease Surveillance and Response system was conducted in all assessment sites. Connectivity challenges at the LGU level limited use of the online reporting system, requiring double data entry and increasing the workload at the provincial and regional levels. In March 2024, the cholera case definition in Eastern Visayas was reverted to require signs of severe dehydration. Following this, surveillance staff observed a decline in health-care workers considering cholera in differential diagnoses. Event-based surveillance training was in progress during the risk assessment.

Confirmation of suspected cases remained limited across Eastern Visayas; awareness of Department Memorandum 2020–0391 on cholera RDTs was minimal, and RDT supplies at the RESU in the City of Tacloban were limited and released only upon request. Additionally, staff training on RDT use was ad hoc and mainly conducted during outbreaks, contributing to low awareness of the testing algorithm.

Specimen collection and transport protocols were established; however, procurement and logistical challenges constrained these activities. While the City of Tacloban had cholera confirmatory testing capacity, Cary Blair medium was unavailable, transportation was irregular, particularly in geographically isolated and disadvantaged areas, and field workers were unaware that the reagent was available from the City of Tacloban and reported sending samples to Manila for testing.

Municipality data management, analysis and reporting capacity were limited, with most analyses conducted at provincial or regional levels, contributing to delays. The RESU provided automated analysis and reports for priority diseases but lacked cholera-specific templates. Surveillance staff expressed a need for training to enhance their data analysis and interpretation skills, along with IT equipment to support surveillance operations. Few staff knew the criteria for officially closing an outbreak or conducting a risk assessment, which warrants training in these areas.

Water, sanitation and hygiene

In most areas visited, water refilling stations were the primary drinking-water source, with families typically paying 25–30 Philippine pesos for a 20-litre container, despite daily incomes as low as 200 pesos. Those unable to afford water from refilling stations relied on a low-cost alternative, such as open wells, rivers, streams or unregulated vendors, and automated *tubig* (water) machines.

Poor water quality was evident in the sampling: all Level I and II samples (13/13) were positive for *E. coli* and total coliform, while Level III samples showed no *E. coli* (0/6) but 33% (2/6) were positive for total coliform (**Table 2**). Potential sources of contamination included proximity to septic tanks (<25 metres, uncontained solid waste, poor drainage and open defecation, particularly in coastal areas with limited toilet access.

Water refilling stations and water districts met DOH requirements for an approved water safety plan under Administrative Order No. 2014–0027. However, other water supply sources managed by the LGU or community lacked established water safety plans.

The region had four DOH-accredited laboratories, which were insufficient for routine monitoring under the 2017 National Standards for Drinking-water.[11] Although portable water testing kits were available, resources for consumables, such as reagents, were often not earmarked by LGUs, contributing to delays and reduced accuracy. Most rural sanitation inspectors reported that they were trained to conduct essential water testing and analysis.

Qualitative insights from discussions with community members indicated that many septic tanks lacked bottom slabs, posing groundwater contamination risks. Official sanitation data often misrepresented conditions due to inconsistent interpretation of indicators, especially those defining safely managed sanitation services.

Open defecation persisted in some areas. For households with toilets connected to septic tanks, desludging costs (3500–6000 pesos), unregulated services and improper septic tank management created

Table 2. **Water sampling results, by water source level, Eastern Visayas, Philippines, 2024**

Local government unit	Water source	No. (%) of samples positive for *E. coli*	No. (%) of samples positive for total coliform
Eastern Samar	Level I	8/8 (100)	8/8 (100)
	Level II	–	–
	Level III	0/4 (0)	2/4 (50)
Subtotal		**8/12 (67)**	**10/12 (83)**
Samar	Level I	3/3 (100)	3/3 (100)
	Level II	1/1 (100)	1/1 (100)
	Level III	–	–
Subtotal		**4/4 (100)**	**4/4 (100)**
City of Tacloban	Level I	1/1 (100)	1/1 (100)
	Level II	–	–
	Level III	0/2 (0)	0/2 (0)
Subtotal		**1/3 (33)**	**1/3 (33)**
All LGUs	Level I	12/12	12/12
	Level II	1/1	1/1
	Level III	0/6	2/6
Grand total		**13/19 (68)**	**15/19 (79)**

LGU: local government unit.

Level I (point source) refers to a protected well or developed spring without a distribution system, serving around 15 households; Level II (communal faucet system) refers to a system with a piping network and communal faucets serving 40–100 households; Level III (individual house connections) refers to a system with household taps suitable for densely populated areas.

additional risks. Informal coastal settlements faced additional WASH-related challenges due to development restrictions. Hand hygiene remained limited by inadequate facilities and cost barriers, with informants reporting that while they understood its importance, they could not afford to keep soap available at handwashing stations specifically for that purpose.

Risk communication and community engagement

Community members demonstrated a basic understanding of cholera symptoms and prevention, often using local terms such as *urosuka* (vomiting and diarrhoea) and *eltur* (cholera). They recognized the link between cholera and contaminated water and food and unsanitary conditions, and were aware of preventive measures, including drinking clean water, boiling water when necessary, covering food, using personal toilets, maintaining cleanliness and practising hand hygiene.

Community engagement activities aimed at enhancing cholera prevention knowledge and practices remained limited in both reach and consistency. Health workers served as the primary facilitators for RCCE initiatives, raising awareness through family development sessions under the 4Ps programme (which supports low-income households), village assemblies and community clean-up drives. The frequency and scope of these activities varied widely across LGUs, and mechanisms for community feedback remained minimal.

EVCHD developed key cholera messaging based on experiences, primarily disseminated through social media channels. Respondents expressed a preference for information, education and communication materials in the local Waray language. However, regional language variations posed challenges for consistent messaging. Colourful printed materials were preferred for their clarity and visual appeal.

High perceptions of cholera risk, shaped by past outbreaks, coexisted with inconsistent health-seeking behaviours. While fear of cholera's severity and hospitalization costs motivated preventive practices, individuals reported seeking health care only when symptoms worsened or when children were affected.

Health workers, particularly village health workers, were identified as highly trusted figures and served as

the primary source of health information and as front-line emergency responders in the communities. They actively engaged in case investigation, referrals, the distribution of sodium hypochlorite solution and oral rehydration solution, health education and case monitoring, and expressed the need for additional training, job aids and resources to support RCCE activities.

DISCUSSION

This joint risk assessment conducted in Eastern Visayas in 2024 identified that partial progress had been made across key technical areas since 2016. Several good practices were documented, including a well established surveillance system with high-frequency reporting (daily during outbreaks and weekly during routine operations) and the demonstrated capacity of sanitation inspectors in water sample collection and handling. Additionally, a high level of cholera risk perception was observed among community members. Despite this progress, most recommendations from the 2016 assessment remained only partially implemented, indicating the need for continued strengthening across technical areas (**Table 1**).

Epidemiological trends in **Fig. 1**, including the decline in incidence after 2022, largely reflect changes in surveillance sensitivity. During the 2022–2023 outbreaks, a broader definition of a suspected case and active RDT use enabled more sensitive detection. In early 2024, the region reverted to the standard, more restrictive EDCS definition that required the presence of severe dehydration, reducing overall case detection. These changes, combined with the overall reduction in outbreak magnitude, contributed to the observed decline in reported incidence.

This assessment further highlighted, through interviews and field observations, the systemic and socioeconomic determinants influencing cholera risk in the Philippines. Effective prevention and response require multisectoral coordination and leadership. The devolution of health services under the 1991 Local Government Code established a decentralized system, with LGUs managing service delivery and DOH providing policy direction and technical support.[18] While decentralization has enabled localized implementation, it has also introduced challenges in procurement, training, outbreak declaration, incident management and interdepartmental coordination. This assessment also emphasized the impact of socioeconomic vulnerability,[19,20] particularly among coastal populations with informal or unstable employment and limited access to WASH services. Although these communities demonstrated high awareness of cholera prevention measures, their ability to act on this knowledge was limited by resource constraints.

Limitations

This assessment had several limitations. First, as a predominantly qualitative study, it did not allow for a systematic evaluation of outbreak response timeliness. Second, reporting bias may have influenced findings; for instance, some self-reported handwashing durations exceeded 10 minutes, which appears to represent an overestimation in the context of limited water availability. Triangulation methods were employed to mitigate this, which included interviews with multiple types of respondents and, when possible, the integration of quantitative data, such as surveillance reports and water quality testing. Third, changes over time to the case definition of suspected cholera, particularly the reversion to a more stringent definition requiring severe dehydration after March 2024, may have affected case detection and limited comparability across different periods. Fourth, the assessment was limited to four municipal sites and one city site in Eastern Visayas, which may restrict the generalizability of findings to other regions in the Philippines.

Conclusions

This risk assessment demonstrated that cholera remains a persistent public health threat in Eastern Visayas, driven by multiple interrelated factors, including limited outbreak response capacity, fragmented governance and insufficient access to WASH services. Addressing these challenges requires a coordinated, multisectoral approach, leveraging existing structures such as the EOC as an integrated response hub and ensuring effective coordination across surveillance, WASH and RCCE.

To address systemic gaps, the development and implementation of national strategies for cholera control should be prioritized to clearly define roles, responsibilities and priority areas across national and local levels. These strategies should be embedded within

the broader national Food and Waterborne Diseases Prevention and Control Program framework to ensure coherence and sustainability. Securing formal, active support from local authorities will be essential in ensuring ownership and sustainability. The strategies should be aligned with the Global Task Force on Cholera Control framework.[21] Furthermore, in line with these findings and water testing results, prioritizing Level I and II water systems for water safety planning, strengthening routine water quality monitoring, and sustaining investments in WASH infrastructure are essential steps for reducing the long-term burden of cholera and other foodborne and waterborne diseases in highly vulnerable areas of the Philippines.[22]

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Conflicts of interest

The authors have no conflicts of interest to declare.

Ethics statement

This study was conducted in accordance with the ethical standards of the Declaration of Helsinki. The methodology was reviewed by the Ethics Review Committee of the WHO Regional Office for the Western Pacific and was granted an exemption from full ethical review because it utilized anonymized secondary data (approval no. WP-2025-DOCS-30682). Written informed consent was obtained from all study participants prior to data collection. In cases where participants were minors or otherwise unable to provide consent, informed consent was obtained from their legal guardians.

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