Research Article

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Quick Response Code:
Website:
https://journals.lww.com/pjhrd
DOI:
10.4103/PJHRD.PJHRD_27_25

Enhancing disaster preparedness through medical laboratory resilience in the Philippines

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Abstract:

Background: The Philippines is among the world's most disaster-prone countries, yet medical laboratories remain an underrecognized component of disaster preparedness and health system resilience. These facilities are essential for disease surveillance, diagnostics, and emergency response, but their operations are frequently disrupted during climate-related disasters and public health emergencies.

Aims and Objectives: This commentary examines the structural, operational, and systemic gaps that limit the integration of medical laboratories into national and local disaster risk reduction and health emergency frameworks.

Materials and Methods: Drawing on global disaster risk reduction frameworks, World Health Organization guidance, regional and international literature, and documented Philippine experiences from infectious disease outbreaks and climate-related disasters, the article highlights how fragmented planning, vulnerable infrastructure, weak digital systems, and communication failures compromise laboratory continuity during crises.

Results: Despite rapid laboratory scale-up during the COVID-19 pandemic, many facilities continued to experience shortages in trained personnel, inconsistent biosafety practices, data loss, and delayed diagnostic services, particularly in disaster-affected and geographically isolated areas.

Conclusion and Recommendations: To address these gaps, the commentary proposes five strategic action areas: institutionalizing laboratory emergency preparedness at national and local levels, upgrading laboratory infrastructure for climate and hazard resilience, strengthening digital health systems to ensure data continuity, establishing redundant and disaster-resilient communication protocols, and deploying mobile and modular laboratory units to maintain diagnostic services during emergencies. Strengthening medical laboratory resilience is essential to sustaining core health services, reducing disaster-related morbidity and mortality, and advancing equitable, disaster-responsive health systems in the Philippines. Achieving this requires sustained policy commitment, multisectoral collaboration, and integration of laboratory preparedness into broader health security, climate adaptation, and universal health care strategies.

Keywords:

Disaster preparedness, diagnostics, health systems resilience, medical laboratories, Philippines.

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Received: 08-04-2025
Accepted: 12-09-2025
Published: 22-12-2025

Introduction

In 2022, the Philippines ranked first in the World Risk Index due to its high exposure to natural hazards, vulnerability, and lack of coping and adaptive capacities.[1] With over 20 typhoons annually, plus frequent earthquakes and volcanic activity, the country is a disaster hotspot.[2] However, disaster preparedness strategies continue to be neglected as a critical component of the health system – medical laboratories. Similarly, World Health Organization's Health Emergency and Disaster Risk Management framework highlights hospitals and clinical facilities but gives

How to cite this article: Ramos AB. Enhancing disaster preparedness through medical laboratory resilience in the Philippines. Philipp J Health Res Dev 2025;29(4):2-7.

limited attention to sustaining laboratory operations during disasters. Converging evidence across global and regional contexts confirms this neglect.[3] In the Philippines, hospital-focused Ebola preparedness workshops temporarily trained medical technologists in biosafety and specimen handling, resulting in significant improvements in knowledge and confidence (knowledge scores rising from a median of 7/10 preworkshop to 9/10 postworkshop), yet these interventions were reactive and not institutionalized.[3]

During the COVID-19 pandemic, Southeast Asian laboratories were rapidly expanded to meet testing demand, with one country scaling to more than 1800 labs by 2021; however, most faced persistent shortages of trained staff, uneven biosafety implementation, and delayed specimen transport.[4] Beyond outbreaks, climate hazards have repeatedly disrupted laboratory continuity: floods in Uganda forced the closure of the Mulago National Referral Hospital laboratory, whereas heat waves destabilized reagents and disrupted supply chains globally.[5] Divergence is seen only in a handful of cases – such as Japan's hospital preparedness initiatives and selected Latin American studies – that explicitly incorporated laboratory resilience into their frameworks, suggesting models that could be adapted elsewhere.[6,7]

This convergence of evidence across regions and hazards substantiates the assertion that laboratories, though indispensable for diagnostics, disease surveillance, and emergency response, remain structurally fragile and systematically overlooked in mainstream disaster and climate adaptation planning.[8] These facilities are essential for diagnostics, disease surveillance, and emergency response, yet remain structurally and operationally fragile.[9]

The COVID-19 pandemic exposed the limitations of laboratory infrastructure, data systems, and surge capacity, especially in far-flung areas.[7] In addition, Super Typhoon Rai (Odette) in December 2021 and recent floods in Mindoro in late 2023 caused major disruptions in laboratory operations –leading to delayed testing, sample losses, and diagnosis gaps in both infectious and noncommunicable diseases.

Institutionalize laboratory disaster preparedness at national and local levels

The Department of Health (DOH), in collaboration with the Philippine Association of Medical Technologists, should develop a National Laboratory Emergency Preparedness and Response Framework aligned with the Health Emergency and Disaster Risk Management strategy by the WHO.[2] Local Government Units (LGUs) are recommended to integrate laboratory preparedness into their Local Disaster Risk Reduction and Management Plans and conduct regular drills and hazard mapping specific to lab operations.[10]

The framework is recommended to be comprehensive, as multihazard approaches in Japan and Latin America have demonstrated reduced disruption of diagnostic services during disasters.[6] A fragmented framework risks overlooking laboratories, leading to delayed detection and treatment capacity. It should also define the roles and responsibilities of laboratory personnel, health authorities, and local disaster risk reduction offices during emergencies. Furthermore, the framework should require the inclusion of laboratories in contingency funding mechanisms, allowing rapid mobilization of emergency resources such as backup power systems, diagnostic supplies, and temporary testing facilities.

To build a culture of preparedness, LGUs are encouraged to institutionalize annual simulation exercises and capacity-building programs for laboratory staff, in partnership with academic institutions and regional training centers, which significantly improve preparedness scores and coordination, as evidenced by simulation-based training in the Philippines during the Ebola preparedness workshops.[3,11] These recommendations are supported by regional findings showing that COVID-19 laboratory networks faced severe shortages of trained personnel and supplies when support systems were not institutionalized.[4] Establishing laboratory emergency preparedness as a mandatory component of health facility licensing and accreditation – through the Health Facilities and Services Regulatory Bureau – can further ensure compliance and sustainability of efforts.[6]

Upgrade infrastructure for climate and hazard resilience

Many laboratory buildings remain vulnerable to storm surges, flooding, and earthquakes, particularly in Regions IV-A, VIII, and BARMM.[12] The National Economic and Development Authority has emphasized the need to retrofit public health infrastructure based on updated geohazard assessments.[11] The Department of Public Works and Highways Resilience Standards (2022) must be strictly enforced, prioritizing structural upgrades of laboratories in high-risk areas.

To operationalize these upgrades, the government is recommended to lead laboratory resilience initiatives, as state-led investments were decisive in rapidly expanding COVID-19 testing facilities in South-East Asia – one country scaling to 1800 laboratories by 2021.[4] The audit should be followed by a phased investment plan led by the Department of Health, with co-funding mechanisms from local governments and development partners such as the World Bank or the Asian Development Bank.[13]

Public–private partnerships may also be explored to accelerate laboratory infrastructure modernization, especially in urban and peri-urban areas.[14] These partnerships can integrate green building principles and energy-efficient systems, aligning with the Philippines' climate mitigation goals. Furthermore, all retrofitting activities should adopt gender- and disability-inclusive designs to ensure equitable access and safe working conditions for all laboratory personnel and patients during disasters.[15]

Adopting modular, prefabricated designs for new laboratory construction in remote or disaster-prone areas can significantly reduce building time and costs while enhancing resilience.[16] Lessons learned from the rapid deployment of temporary health facilities during the COVID-19 pandemic should be incorporated into infrastructure planning for laboratories.[17] Finally, the integration of early-warning systems and hazard-monitoring tools – such as seismic sensors or flood alarms – into laboratory design is advisable to support timely evacuation and risk-communication protocols.[18]

Strengthen digital health systems for data continuity

The loss of laboratory data during disasters remains a major concern. Following the National Health Data Repository roadmap, laboratories are advised to transition to cloud-based, encrypted, and interoperable Laboratory Information Systems (LIS) with offline access.[19] Compliance with the Data Privacy Act of 2012 ensures legal and ethical safeguards for patient information during emergency response.[20]

To implement this transition effectively, a national assessment of LIS adoption rates, functionality gaps, and cybersecurity readiness should be conducted across government and private laboratories.[21] The DOH, through its Knowledge Management and Information Technology Service, should issue national technical standards and provide incentives for system upgrades, especially for underfunded provincial and municipal laboratories.[22]

In addition to data protection, digital health systems should be integrated with national surveillance and reporting platforms such as the Epidemiology Bureau's Event-Based Surveillance and Response and the Philippine Integrated Disease Surveillance and Response systems.[23] This integration ensures interoperability and data continuity during disasters, consistent with WHO guidance on laboratory information systems and supported by recent evidence that electronic networks enhanced pandemic surveillance in SEAR countries.[4] Seamless data sharing between laboratories and epidemiological units enables the timely detection of outbreaks and informed disaster response.[24]

Laboratories are encouraged to adopt continuity plans for digital operations, including regular data backups in geo-redundant cloud environments, maintenance of alternative internet connections, and use of battery-powered or solar-powered ICT infrastructure.[25] These measures will ensure LIS functionality even during prolonged power outages or Internet disruptions. Capacity-building programs on cybersecurity, data management, and digital literacy for laboratory staff should also be institutionalized to build long-term system resilience.

Finally, partnerships with tech providers, research institutions, and public health data hubs can foster innovation in laboratory informatics, such as the use of artificial intelligence-assisted data analysis, blockchain-secured recordkeeping, and mobile LIS applications to extend diagnostic reach in field settings and emergency zones.[26]

Establish redundant communication protocols

Timely coordination among laboratories, health facilities, and emergency responders is often impaired by communication breakdowns during disasters.[27] The National Disaster Risk Reduction and Management Council recommends redundant channels such as satellite phones, portable radios, and secured messaging apps like VaxCertPH Connect.[11]

To strengthen communication resilience, laboratories should be equipped with multiplatform communication systems that allow real-time updates even in low-connectivity or nonconnectivity zones.[28] These should include SMS alert systems, handheld radio units, and mesh networks capable of functioning independently of commercial telecommunications infrastructure. In addition, establishing dedicated emergency communication hotlines between regional laboratories and local emergency operations centers can streamline coordination during crises.[29]

Laboratory staff must undergo regular orientation on the proper use of alternative communication tools and protocols, including training on radio operation, encrypted communication apps, and satellite phone handling.[28] Simulation exercises should include communication failure scenarios to test and refine laboratory-specific response protocols.[30]

Furthermore, partnerships with the Department of Information and Communications Technology can support the rollout of secure, disaster-resilient ICT infrastructure, particularly in geographically isolated and disadvantaged areas. Embedding laboratory communication protocols within broader Health Emergency Operation Plans ensures they are synchronized with the response frameworks of hospitals, LGUs, and regional DRRM councils.[31]

By institutionalizing these measures, laboratories will be better able to relay urgent diagnostic data, coordinate sample transport, and issue alerts on disease outbreaks – contributing to more cohesive and timely public health responses during emergencies.

Deploy mobile and modular laboratories

Inspired by the mobile biosafety labs used during COVID-19 in Vietnam and Indonesia, the Philippines must invest in mobile or containerized laboratories prepositioned in hazard-prone areas.[32] These can provide essential diagnostics when fixed laboratories are inaccessible. In 2023, WHO piloted a mobile lab network in Mindanao for cholera and leptospirosis surveillance, demonstrating feasibility and effectiveness.[33]

These laboratories are designed for rapid deployment and are often equipped with essential biosafety features, power supplies, water filtration, and air-handling systems, making them suitable for a wide range of settings, including evacuation centers, temporary health camps, and rural barangay health stations. By leveraging solar power and hybrid energy systems, mobile laboratories can operate autonomously even in areas with unstable power grids.

To ensure operational efficiency, the Department of Health should establish a national deployment protocol and stockpile strategy that includes site assessment guidelines, transportation logistics, and maintenance procedures for mobile lab units. Regional laboratory hubs can act as staging areas to facilitate faster mobilization based on predictive hazard alerts or active emergencies.[32]

Moreover, mobile laboratories must be interoperable with existing health information systems and surveillance platforms to enable seamless integration of diagnostic data into national reporting workflows. The inclusion of mobile PCR testing capabilities, rapid antigen diagnostics, and cold storage for specimen preservation expands their utility in both outbreak response and routine disease surveillance.

Capacity building is also critical. A dedicated pool of trained mobile lab technicians, logistics personnel, and biosafety officers should be organized and regularly deployed for drills and humanitarian missions. Collaborations with academic institutions and private partners can sustain training pipelines and innovation in modular lab design, ensuring these assets remain responsive to evolving threats such as zoonotic spillovers, emerging pathogens, and climate-exacerbated disease outbreaks.[34]

Broader implications

The Sendai Framework for Disaster Risk Reduction (2015–2030) emphasizes the protection and continued functionality of critical infrastructure, including healthcare laboratories, during disasters.[35] During Super Typhoon Odette (2021) several provincial hospitals in Visayas reported days-long delays in laboratory confirmation of leptospirosis and dengue, underscoring how natural disasters can directly impair diagnostic capacity in the Philippines.[36]

These systemic weaknesses are compounded by evidence from Metro Manila, where a prospective study of 1315 patients revealed that bloodstream infections due to *Staphylococcus aureus*, *Salmonella Typhi*, *Escherichia coli*, and *Neisseria meningitidis* were associated with a 15.2% case fatality rate among culture-positive patients – significantly higher than those with negative cultures (4.4%).[36] Importantly, over half of *S. aureus* isolates were methicillin-resistant (MRSA ST30, USA1100 clone), highlighting the urgent need for laboratory capacity to detect and monitor antimicrobial resistance during crises.[36]

This convergence of disaster-related service disruption and endemic AMR threats demonstrates that laboratory resilience is not only critical for maintaining routine diagnostics but also central to reducing mortality during health emergencies in the Philippines.[36] Given the country's high vulnerability to natural hazards, the integration of laboratory preparedness across multiple dimensions – structural safety, data security, communication interoperability, operational continuity, and workforce capacity – is imperative.

With the institutionalization of disaster preparedness planning (Action Area 1), laboratories become embedded in coordinated local and national emergency response frameworks. Infrastructure upgrading (Action Area 2) ensures their physical survivability, while digital transformation (Action Area 3) protects the integrity of patient data and enhances reporting efficiency.[19,25] Redundant communication systems (Action Area 4) secure real-time coordination during crises, and mobile laboratories (Action Area 5) offer flexible solutions for hard-to-reach and high-risk locations.

By aligning laboratory preparedness with the principles of Universal Health Care, climate adaptation strategies, and sustainable development goals, the Philippines can not only minimize disaster-induced service disruption but also achieve health equity and resilience at the community level.

Conclusion

Medical laboratories are foundational to disaster-responsive health systems yet remain a blind spot in national resilience planning. Investing in the structural, operational, and digital resilience of these facilities must become a national priority. The five strategic actions outlined – ranging from policy reforms to infrastructure retrofitting, technological integration, and mobile deployment – demonstrate a holistic approach to strengthening laboratory preparedness.

Acknowledgment(s)

The author acknowledges the guidance and mentorship received from colleagues and faculty at the De La Salle Medical and Health Sciences Institute.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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