



Improving Linkages between Public Health Functions and Organizations

A Framework for National Public Health Institutes

United States Centers for Disease Control and Prevention

February 2024



**CENTERS FOR DISEASE
CONTROL AND PREVENTION**

FOREWORD



We now have a vision for how public health systems can improve coordination and collaboration, based on learning from the COVID-19 epidemic

The COVID-19 pandemic underscored, in unprecedented ways, the critical role of public health institutions and the functions they perform. We observed how the effective performance of essential functions such as disease surveillance, laboratory services, and health communications were not only critical to our collective health, but also to our livelihoods. We further witnessed how breakdowns in coordination between public health institutions and among public health functions hampered our ability to prevent and control the disease.

The pandemic revealed the imperative for public health institutions to work in synergy with key partners. Halting transmission, ensuring quality care, and administering vaccines depended on effective, real-time coordination between researchers, epidemiologists, laboratorians, clinicians, regulators, health departments, community organizations, the private sector, and policymakers. Policies affecting schools, workplaces, and social life demanded innovative means of collecting scientific data and joint decision-making between sectors.

Where public health institutions and essential functions were coordinated well and had support from policymakers, lives were likely saved. This coordination – or linkages – provides optimism for the future. In support of U.S. CDC's Moving Forward strategy, we have developed this framework to highlight the benefits of public health linkages. Linkages better prepare us to prevent, detect, and respond equitably to the next public health threat.

**Dr. Kayla Laserson, Director
Global Health Center, U.S. CDC**

ACKNOWLEDGEMENTS

This framework was developed by the U.S. Centers for Disease Control and Prevention (CDC), Division of Global Health Protection under the leadership of Shelly Bratton and Dennis Jarvis, working in collaboration with Alexandra Zuber, Jonathan Pearson, and Yesser Sebeh of Ata Health Strategies, LLC.

Although many experts participated in the development of this framework, the authors would like to recognize the contributions of the following organizations: Georgia National Center for Disease Control and Public Health, Nigeria Centre for Disease Control, Korea Center for Disease Control and Prevention, Colombia Instituto Nacional de Salud, Norwegian Institute of Public Health (Folkehelseinstituttet), Institut National de Santé Publique – Burkina Faso, Resolve to Save Lives, and the International Association of National Public Health Institutes.

Support was provided under cooperative agreement number NU2HGH000044-01-00 with TEPHINET. For further information, contact the U.S. CDC Division of Global Health Protection National Public Health Institute Program.

Suggested citation: U.S. Centers for Disease Control and Prevention. 2024. "Improving Linkages between Public Health Functions and Organizations. A Framework for National Public Health Institutes."

PUBLIC HEALTH LINKAGES

Practical, replicable activities or actions that facilitate collaboration between public health functions or organizations to improve public health impact



LINKAGE ENABLERS

Institutionalized processes, assets, and organizational characteristics that strengthen public health linkages

	<ul style="list-style-type: none">i Executive Summaryii Acronyms and Abbreviations
Section I: Introduction and Concepts	<ul style="list-style-type: none">02 Introduction05 Concepts and Definitions06 Evidence for the Benefits of Linkages07 Linkage Principles
Section II: Introducing Linkages	<ul style="list-style-type: none">11 Functional Linkages Between Public Health Functions19 Multilevel Linkages21 Multisectoral Linkages23 International Linkages
Section III: Developing Linkages	<ul style="list-style-type: none">29 Enablers of Public Health Linkages34 Seven Steps NPHIs Can Follow to Implement Public Health Linkages and Enablers35 Linkage Opportunities for National Public Health Institutes
Section IV: Appendices	<ul style="list-style-type: none">41 Appendix A. Country Case Studies49 Appendix B. Functional Linkage Reference Tables



Useful Tools

- 34** Seven Steps for Linkages
- 35** Linkage Opportunities for National Public Health Institutes
- 41** Country Case Studies
- 49** Functional Linkage Tables

EXECUTIVE SUMMARY

This framework provides a typology for public health linkages and the factors that support them (i.e., enablers), detailed examples of key linkage types, and in-depth case studies of country-led impacts resulting from effective linkages.

National public health institutes (NPHIs) serve as an institutional “home” to public health systems and expertise in countries around the world. Upon its launch in 2006, the International Association of National Public Health Institutes brought worldwide attention to their role. The U.S. Centers for Disease Control and Prevention (CDC) has supported the development of more than 40 NPHIs since 2011. Globally, U.S. CDC has observed the increasing integration or coordination of essential public health functions under the direction of NPHIs. In the absence of NPHIs, these public health functions may operate disjointedly, with limited coordination in their funding or execution.

Integrating or coordinating public health functions under an NPHI (or another centralized health authority) has numerous impacts. NPHIs can concentrate financial, personnel, and material resources within a single organizational structure, enabling greater alignment to shared public health goals, stronger accountability measures, and enhanced generation and sharing of knowledge and data for standardized, evidence-based practice. NPHIs can also facilitate and enable rapid decision-making and the efficient use of resources in times of public health crisis. Strengthening horizontal interactions and linkages across public health functions can enhance performance and efficiencies in health systems that are often less feasible with traditional, vertical approaches.

This framework summarizes the evidence base for linkages, defines and describes common linkage types, and documents real-world examples of linkages and their enablers. Our objective is to share practical information on the benefits of fostering linkages with public health leaders to improve public health impact.

ACRONYMS AND ABBREVIATIONS

AMR	Antimicrobial resistance
EBSCO	Elton Bryson Stephens Company
EOC	Emergency operations center
EPHF	Essential public health function
EVD	Ebola virus disease
FETP	Field Epidemiology Training Program
FMOH	Federal Ministry of Health
HCV	Hepatitis C virus
IANPHI	International Association of National Public Health Institutes
IHR	International health regulation
IMS	Incident management structures
JEE	Joint external evaluation
KDCA	Korea Disease Control and Prevention Agency
LHDI	Local Health Department Initiative
MERS	Middle Eastern Respiratory Syndrome
MOH	Ministry of health
MOU	Memorandum of understanding
MSPP	Ministry of public health and population
NCDC	National Center for Disease Control and Public Health (Georgia)

ACRONYMS AND ABBREVIATIONS

NPHI	National public health institute
PHE	Public Health England
PHEOC	Public Health Emergency Operations Center
PPE	Personal protective equipment
REDISSE	World Bank Regional Disease Surveillance Systems Enhancement
RKI	Robert Koch Institute
RRT	Rapid-response team
SOP	Standard operating procedure
SORMAS	Surveillance Outbreak Response Management and Analysis System
U.S. CDC	United States Centers for Disease Control and Prevention
WHO	World Health Organization

SECTION I – INTRODUCTION AND CONCEPTS

INTRODUCTION

The U.S. CDC's NPHI Program is helping to build a network of accountable, efficient, proactive, and science-focused public health agencies that use data to drive decision-making, promote health equity, and contain health threats at their source.

Background

The COVID-19 pandemic illustrated the profound role public health systems play in protecting the economic and social well-being of societies. Breakdowns in the delivery of core public health functions can lead to devastating impacts, even in the most industrialized nations.

National public health institutes (NPHIs) are often a cornerstone of a country's public health response to pandemics and other health threats. As the International Association of National Public Health Institutes (IANPHI) describes, NPHIs are "science-based organizations (or network of organizations) that provide leadership and coordination for public health at the national level." [1] An NPHI establishes a "focal point" for public health, enabling key public health functions to operate synergistically and collaboratively to improve population health outcomes, including health equity. Without an NPHI, a country's public health functions may be implemented in parallel silos—without joint planning, leadership, or coordination—and often by different institutions or sectors. Achieving a country's public health mission often depends on the ability of complex, interdependent systems to perform in concert.

Therefore, how public health functions interact and promote enhancements to public health practice is a critical area of investigation. The U.S. Center for Disease Control and Prevention (U.S. CDC) NPHI Program has developed this framework to provide information on how NPHIs can strengthen the interactions, or "linkages," among public health functions and organizations to improve public health impact. This document recognizes that some countries do not have an NPHI and other health authorities (e.g., health ministry) may advance linkages, depending on the country's unique health system.

INTRODUCTION

NPHI leadership can take concrete, evidence-based actions to foster linkages between essential public health functions (EPHFs) and organizations for better health outcomes.

Purpose and Intended Audience

The purpose of this document is to provide public health leaders with information about public health linkages and the conditions that foster them, also known as enablers. It also supplies information on practical approaches public health leaders may consider using to strengthen linkages and their enablers for improved public health impact in their own national contexts. Intended audiences for this document include staff and leadership at organizations such as:

- NPHIs
- IANPHI
- Public health researchers and practitioners
- Country-level entities supporting the coordination of public health functions (e.g., health ministries, security agencies)

Foundation of These Guidelines

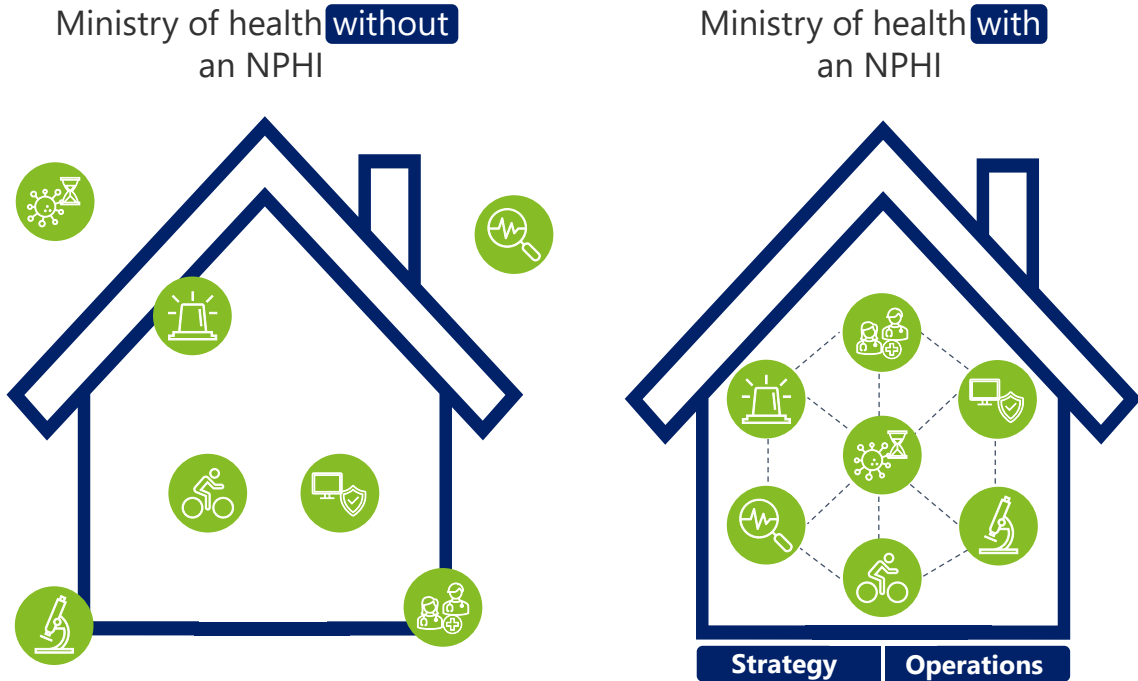
In 2020, U.S. CDC and its partners conducted a multi-disciplinary review of the literature on functional linkages. Using a systematic strategy, the team searched Medline, Elton Bryson Stephens Company (EBSCO) Global Health, and Business Complete Databases and reviewed 92 articles from the public health and organizational capacity-development literature.

U.S. CDC then conducted informal consultations with 16 global subject-matter experts, who represented leaders of NPHIs, the U.S. CDC NPHI Program, IANPHI, and technical experts in key public health functions (e.g., laboratory, workforce). U.S. CDC validated this document via interviews with nine leaders from three NPHIs, who provided further content for the appendix case studies. Finally, U.S. CDC conducted a formal stakeholder review with experts from IANPHI, U.S. CDC, and the World Health Organization (WHO).

NPHIs Facilitate Public Health Linkages

The Benefits of Establishing an NPHI

U.S. CDC began directly supporting NPHI development in 2011. U.S. CDC supports countries to create NPHI structures that bring functions together and support functional and organizational linkages for public health. Without an NPHI, multiple institutions and even sectors may implement public health functions, often in parallel and without joint planning, leadership, or coordination. NPHIs can assist in overcoming these challenges by bringing essential activities within a single institutional home with shared objectives, plans, staff, and funding. This is illustrated in the figure below.



Source: NPHI Program, Center for Global Health, U.S. CDC, 2020



CONCEPTS AND DEFINITIONS

This framework focuses on a subset of EPHFs identified in IANPHI's Framework for NPHI Development, which are a common priority of NPHIs: (1) workforce development, (2) surveillance, (3) research, (4) laboratory services, (5) health promotion, (6) outbreak response, and (7) emergency management

Essential Public Health Functions

Global frameworks recommend a set of essential public health services countries should undertake. [2–6] This document focuses on a subset of these functions: (1) public health workforce development, (2) surveillance, (3) public health research, (4) public health laboratory services, (5) health promotion, (6) outbreak response, and (7) emergency management.

Linkages

Linkages are actions that improve coordination between EPHFs and/or institutional actors. They improve system capacities to prevent, detect, and respond to public health threats and improve population's health. Linkages are generally tactical in nature and developed by NPHIs and their partner organizations. Below is a simple typology, defining five types of linkages:

Functional: between two public health functions

Multifunctional: between three or more public health functions

Multisectoral: between government, private, academic, and nongovernmental sectors, or between sectors within the government

Multilevel: between national and subnational levels of the health system

International: between NPHIs and health entities in other countries, including multilaterals

Enablers

Enablers are institutionalized processes, assets, and organizational characteristics that foster and strengthen public health linkages. Frequently, they are factors in the macro-level health system and include organizational culture, behavior, or relationships. Enablers were drawn from literature and validated by interviews with NPHI leaders. [7]

EVIDENCE FOR THE BENEFITS OF LINKAGES

Linking public health functions under a common framework or institute enables better coordination of health system actors and a comprehensive approach to addressing public health. [8]

Benefits of Public Health Linkages

The benefits of linkages are well documented in public health and organizational development literature. Linkages have been shown to introduce efficiency in the use of resources, improve availability and flexibility of public health resources, and enhance team performance and the quality of public health programs.

From a resource perspective, linkages can streamline management of personnel, processes, and resources. [9] They enable more effective coordination, leadership, and management of public health activities. [9] In multiple studies, linkages led to more efficient coordination of epidemiologists, laboratorians, scientists, and program authorities to detect and control outbreaks. [10–13] In the private sector, cross-functional collaboration has been shown to create cost savings and reduce “siloing” of organizations or functions, as well as to lead to new product development and innovation. [13,14]

Organizational performance benefits from linkages. With greater collaboration across teams, linkages facilitate conflict resolution and improve the amount of information an organization can absorb and process. [15,16] Employing linkages enables more effective coordination, leadership, and management of public health activities and more systematic application of evidence-based methods of public health across multiple health threats. [9,17,18] Finally, and perhaps most importantly, linkages improve capacity to mount a quick, decisive, and coordinated response to public health emergencies. [9,11] NPHIs can use linkages to improve prevention, detection, and response to public health threats through functional and organizational coordination. [6,19]

Five Principles for Design and Deployment of Linkages



Purposeful

Result from intentional design, leadership commitment, and resource investments; may be targeted for a specific problem or general public health operations



Adaptable

Able to shift or flex based on needs, whether temporary or permanent, formal or informal, or high- or low-intensity needs



System-specific

Tailored to the unique characteristics of each county's health system and delivery modalities



Prioritized

Focused on maximizing public health impact or resource efficiency



Conjoined

Often deployed in combination with each other or interdependently, in the context of a public health program or campaign

Endnotes for Section I: Introduction and Concepts

1. The International Association of National Public Health Institutes (IANPHI). n.d. *Mission, Vision and Values*. <https://ianphi.org/about/mission.html>.
2. IANPHI. n.d. *National Public Health Institutes Core Functions and Attributes*. Accessed Aug 4 2022. https://www.ianphi.org/_includes/documents/sections/tools-resources/nphi-core-functions-and-attributes.pdf.
3. World Health Organization. Regional Office for Europe. 2015. *Self-assessment tool for the evaluation of essential public health operations in the WHO European Region*. <https://apps.who.int/iris/handle/10665/344398>.
4. World Health Organization. n.d. *Essential Public Health Functions*. <https://www.who.int/teams/primary-health-care/health-systems-resilience/essential-public-health-functions>.
5. Public Health Infrastructure Center. 2023. *CDC 10 Essential Public Health Services*. <https://www.cdc.gov/publichealthgateway/publichealthservices/essentialhealthservices.html>.
6. IANPHI. 2012. "Report of Bellagio Meeting: Role of Essential Public Health Functions, National Public Health Institutes, and IANPHI in 21st Century."
7. Zuber, A., J. Pearso, Y. Sebeh, et al. 2023. "Essential public health functions are not enough: fostering linkages between functions through National Public Health Institutes improves public health impact." *BMJ Glob Health Published Online First*: doi:10.1136/bmjgh-2023-011728.
8. Bloland, P., P. Simon, B. Burkholder, et al. 2012. "The Role of Public Health Institutions in Global Health System Strengthening Efforts: The US CDC's Perspective." *PLoS Med*; 9. doi:10.1371/JOURNAL.PMED.1001199.
9. Koplan, J.P., D. Butler-Jones, T. Tsang, et al. 2013. "Public health lessons from severe acute respiratory syndrome a decade later." *Emerg Infect Dis*;19:861–3. doi:10.3201/eid1906.121426.
10. Barzilay, E.J., H. Vandi, S. Binder, et al. 2018. "Use of the Staged Development Tool for Assessing, Planning, and Measuring Progress in the Development of National Public Health Institutes." *Health Secur*;16:S18–24. doi:10.1089/hs.2018.0044.
11. Njidda, A.A.M., O. Oyebanji, J. Obasanya, et al. 2018. "The Nigeria Centre for Disease Control." *BMJ Glob Health*;3:e000712. doi:10.1136/bmjgh-2018-000712.
12. Petersen, L.R., A. Ammon, O. Hamouda, et al. 2000. "Developing national epidemiologic capacity to meet the challenges of emerging infections in Germany." *Emerg Infect Dis*; 6:576–84. doi:10.3201/eid0606.000605.
13. Kaas, H-W and S. Ohl. 2002. "The next word in cost reduction." *McKinsey Quarterly*: 16. link.gale.com/apps/doc/A85411373/AONE?u=anon~e1d7b89f&sid=googleScholar&xid=bf7a1595.

Endnotes for Section I: Introduction and Concepts

14. Boven, R. 2011. "What government can learn about silos." *NZ Business*; 25:11.
<https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,shib&db=bth&AN=62132200&site=ehost-live&scope=site&custid=gsu1>.
15. Lawrence, P.R. and J.W. Lorsch. 1967. "Differentiation and Integration in Complex Organizations." *Adm Sci Q*;12:1. doi:10.2307/2391211.
16. Ford, R.C. and W.A. Randolph. 1992. "Cross-Functional Structures: A Review and Integration of Matrix Organization and Project Management." *J Manage*; 18:267–94.
doi:10.1177/014920639201800204.
17. McGuinness, C., D.W. Secombe, J. Frohlich, et al. 2000. "Laboratory standardization of a large international clinical trial: The DAIS experience." *Clin Biochem*; 33:15–24.
doi:10.1016/S0009-9120(99)00081-8.
18. Omanić, A., A. Kurspahić-Mujčić, J. Omanić, et al. 2005. "Evolution of Quit & Win program carried through 2002 year in FB&H." *Bosn J Basic Med Sci*; 5:77–80.
doi:10.17305/bjbms.2005.3340.
19. Jousilahti, P. 2006. "Improving the world's health--the role of National Public Health Institutes." *Cent Eur J Public Health*; 14:3–5. doi:10.21101/CEJPH.B0052.

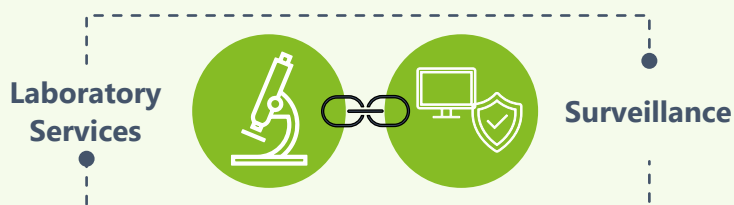
SECTION II – INTRODUCING LINKAGES

FUNCTIONAL LINKAGES BETWEEN TWO PUBLIC HEALTH FUNCTIONS

Surveillance and laboratory are two of the most interdependent public health functions.

Linkages between Laboratory and Surveillance Functions

Surveillance and laboratory services are highly interdependent public health functions. [1,2] Laboratory services produce information related to disease incidence, pathogen identification, environmental testing, genotyping, and more. Epidemiologists use this information to understand disease transmission and design control interventions. [3] Likewise, epidemiologists communicate with laboratories on how the data are used to inform and improve laboratory data collection and management. [4-8]



NPHIs often bring together laboratory and surveillance teams under one institutional home. Some NPHIs have a laboratory data team that conducts epidemiological analysis to identify clusters or anomalies for early outbreak detection.

NPHIs have been shown to facilitate bi-directional sharing of information by developing standardized protocols for sharing specimens and genotyping data between multiple laboratories that make up a network. NPHIs often establish communal data platforms that laboratorians, epidemiologists, and researchers can use to query data. [9]

NPHIs also may create data-sharing procedures, data standards, and nomenclature agreements for shared terms. In addition, they produce epidemiological bulletins that bring together laboratory and surveillance data into a unified shared product. [8]

Enablers of Laboratory and Surveillance Linkages

Linkages between laboratory and surveillance functions benefit from sustained, collaborative leadership.

As with many functional pairings, linkages between laboratory and surveillance are facilitated through clear identification and definition of shared objectives and accountability for outcomes. Research shows that proximity or co-location of staff from both functions—including embedding staff from one function in another—is beneficial. [10,11] Jointly training laboratorians and epidemiologists, either during pre- or in-service, such as through simulations or Field Epidemiology Training Programs (FETPs), can lay a foundation for future joint work. [12,13] Often, NPHIs jointly deploy these staff during an outbreak response and both previous training exposure to joint approaches and communal standard operating procedures (SOPs) can help provide predictability for collaboration. [11] Shared information systems allow for common nomenclature and rapid, shared access to data—especially critical during outbreak responses. [9,14]

Linkages in Action

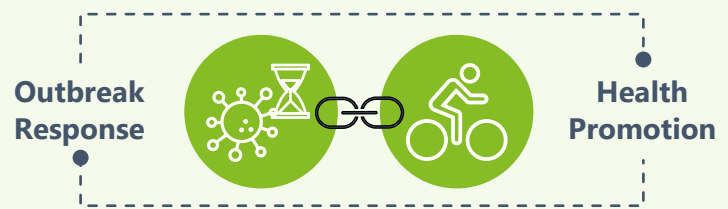
The U.S. CDC PulseNet program maintains close linkages between laboratory and surveillance services for the early detection and control of food-borne, water-borne, and zoonotic diseases. A network of over 80 laboratories submit genotyping data from outbreak samples to national databases. Epidemiologists at U.S. CDC analyze the data for disease clusters and initiate the epidemiological investigation process. [15]

The cloud-based PulseNet platform enables laboratory and surveillance teams to work on joint products. It also intentionally designs national and regional meetings in a manner that brings together laboratory and surveillance professionals to learn best practices from both fields. Joint training is additionally made available for participants to learn key concepts from both disciplines. [15]

FUNCTIONAL LINKAGES BETWEEN TWO PUBLIC HEALTH FUNCTIONS

Linkages between Outbreak Response and Health Promotion Functions

NPHIs can promote linkages between outbreak response and health promotion functions through risk communication, which informs the public how to reduce exposure to disease and prevent disease transmission. [2,15] Linkages also occur through the provision of information on vaccines and therapeutics or non-medical interventions (e.g., use of bed nets), or through communication of risk assessments and risk severity indices related to a disease outbreak. [16,17]



During the COVID-19 pandemic, many NPHIs provided evidence-based messages to the public on masking, hand washing, social distancing, and vaccine efficacy and availability, based on information from the response.

NPHIs can support these linkages by training health promotion staff on outbreak response processes and activities before emergencies occur. [14] They may also facilitate expedited bidirectional exchanges of information between responders and public health communicators to make sure messages are current, impartial, and relevant. [9,14]

NPHIs can establish and maintain working groups to identify and develop coordinated policies and procedures for health communications and community engagement during outbreaks and emergencies. These policies and procedures are often articulated in strategic response plans. [11,14]

NPHIs may provide guidance for communicating with key populations or groups that have been marginalized with specialized, culturally-sensitive messaging during an outbreak response.

Enablers of Linkages Between Outbreak Response and Health Promotion Functions

A critical enabler is an institutional culture that recognizes the importance of health promotion to outbreak response leaders' and staff's disease control.

To strengthen these linkages, NPHIs can make sure plans and SOPs are in place to govern risk communication during a disease outbreak. These plans can be specifically tailored to national, provincial, and local levels. Outbreak response teams that recognize the importance of health promotion to the response effort and support these teams with real-time data and information can enable strong linkages. [11,14,15]

Community engagement systems that track local input on outbreak response efforts and respond to misinformation strengthen health promotion during an outbreak response. These systems can also be used to monitor equitable delivery of response activities. An NPHI that is seen as a primary, trusted, and authorized source of public health messaging is also a critical enabler. [5]

Linkages in Action

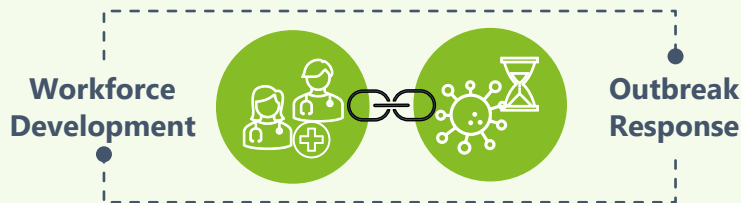
COVID-19 outbreak response teams worldwide provided health promotion staff with real-time data on communities with elevated disease risk to enable targeted risk communication. For example, NPHIs in South Korea and Ukraine targeted messages at religious congregants, while Public Health England provided webinars on how employers could mitigate occupational health exposures for employees, both at-risk communities for COVID-19 transmission. [18]

To eliminate polio, Ethiopia employed health extension workers to engage in ongoing intensive health education, vital registration, and case detection activities in high prevalence jurisdictions. Research found that the strategy was particularly effective for improving relationships with the community, overcoming resistance, and ultimately, increasing demand for polio vaccination. [19]

FUNCTIONAL LINKAGES BETWEEN TWO PUBLIC HEALTH FUNCTIONS

Linkages between Outbreak Response and Workforce Development Functions

NPHIs are commonly involved in planning and developing a nation's public health emergency response workforce. [20] NPHIs can deploy staff during active outbreaks through various mechanisms, including by creating specific cadres (e.g., contact tracers or vaccine deployers) and providing just-in-time training to response support staff. [21,22] They may also support advanced education and certification in epidemiology, laboratory, informatics, and other disciplines that support outbreak response. [15]



Outbreak response teams NPHIs support have been observed to have an impact beyond their core response function, improving the capacity of the subnational workforce.

NPHIs may additionally produce public health workforce plans and strategies to identify the categories and competencies of health workers who can support outbreak response and develop staffing targets for the health system. [15]

Further, outbreak response teams NPHIs support have been observed to impact more than just their core response function, helping develop capacity of the subnational workforce or local-level municipalities. NPHIs routinely provide FETPs for epidemiologists, laboratorians, veterinarians, and incident management staff at all levels of the health system. Where they are present, FETP residents are often the first to be deployed to conduct disease investigation and outbreak response. NPHIs also support topic-specific communities of practice among health workers for peer learning and problem solving. [4]

Enablers of Linkages between Workforce and Outbreak Response Functions

Partnerships with universities and collaboration with global organizations, such as WHO or IANPHI, can support staff development for outbreak response and other needs.

NPHIs can clarify the role of staff during outbreak investigations by creating, in advance, agreements with subnational health entities. [9,15] They can set standard protocols to determine the triggers and procedures for staff deployment. [11,14,15] These measures promote predictability and staffing efficiency. [16,23,24] Feedback loops between staff and response leaders are also shown to be important to maintain situational awareness. Many NPHIs provide ongoing training to prepare staff for rapid deployment. [21,22] Some produce staff development plans or conduct long-term training to support staffing targets at various levels of the health system. Partnering with universities and global networks, such as the WHO Global Outbreak Alert and Response Network or the Global Field Epidemiology Partnership, can enhance capacity for response.

The European CDC leads a two-year fellowship program to train professionals in detection and management of diseases. Fellows actively support outbreak investigations, producing outbreak reports or peer-reviewed manuscripts as outputs. Fellows are placed at sites (e.g., Norwegian Institute of Public Health) with a mandate to work on outbreak response or other EPHFs. [32]

Linkages in Action

In 2019, Angola created and trained a rapid-response team (RRT) with members from the armed forces and staff from the ministry of health. This multifunctional RRT has experts from epidemiology, laboratory, communications, and other cadres. It can mobilize quickly to address outbreaks and other disasters and deploy locally, nationally, or internationally. It sent 54 members to support response efforts in Mozambique after cyclone Idai. [27]

FUNCTIONAL LINKAGES BETWEEN THREE OR MORE PUBLIC HEALTH FUNCTIONS

NPHIs commonly facilitate linkages between three or more functions in the context of a disease control program, campaign, or public health emergency.

Multifunctional Linkages

NPHIs commonly facilitate linkages between three or more functions in the context of a disease control program, campaign, or public health emergency. Many NPHIs plan their interventions based on a combination of laboratory and surveillance data and impact evaluations and other public health research. [2] To be the most effective, disease control programs usually must deploy multiple functions in conjunction, including laboratory, surveillance, workforce, public health research, and health promotion. [2,15]



Public health communication campaigns can join surveillance, laboratory, and health promotion teams to deliver behavior change messaging that is culturally appropriate and targets at-risk communities. Campaigns also use public health research to craft and evaluate messages on individual behavior and/or vaccine uptake. [15]

Public health emergencies further highlight the benefits of combining surveillance and laboratory data with public health research to guide all levels of national policymaking, including testing, vaccine eligibility, quarantine, school closure, and more. Building the capacity of RRTs before and during emergency response is a key intervention. Response teams' sharing of surveillance, laboratory, and research data with health promotion staff can help make sure that risk communication supports the overall pathogen control efforts. [15]

Enablers of Multifunctional Linkages

NPHIs – through consistent and strong leadership – can create a culture where linkages across multiple functions are encouraged and expected.

NPHIs – through consistent, strong leadership – can create an organizational culture where linkages across multiple functions are encouraged and expected. Co-location within an NPHI on a single campus can help to build trust and enable more rapid communication across functional teams. [28–30] Emergency operations centers (EOCs) can create a physical space and SOPs for cross-functional collaboration. [11,14,15,21]

Linkages may facilitate the development of joint work, beginning with producing health promotion products, that can be cultivated over time to produce more complex collaborative work by organizing frameworks such as the International Health Regulations (IHRs). NPHIs can further establish inter-functional platforms, including communities of practice with representatives from multiple functions learning together. [14,15]

Linkages in Action

To address rising cases of antimicrobial resistance (AMR), Vietnam developed the first-ever AMR sentinel surveillance system involving 16 laboratories and six hospitals to track and report health care-associated bloodstream and urinary tract infections. It trained a cadre of clinical “champions” to improve infection prevention and control at facilities nationwide. It conducted quality assessments of laboratories, training, and mentoring labs in need. [31]

During a 2010 cholera outbreak, Haiti’s Ministry of Public Health and Population (MSPP) deployed teams to investigate reports of cholera infections. National labs confirmed infections within hours. The MSPP adjusted strategies based on new information research produced, including case-control studies and mortality surveys. These examples highlight multifunctional linkages. [3]

MULTILEVEL LINKAGES

Linkages between Multiple Levels of the Health System

Multilevel linkages occur between national-level entities, such as an NPHI, and those at a subnational level. Where NPHIs do not possess infrastructure at subnational levels of the health system, several NPHIs cited these linkages as critical for executing their public health mission. For example, many NPHIs are often dependent on local health departments and health care facilities for the provision of routine, sentinel, or syndromic surveillance data that can be aggregated nationally and combined with other data sets to improve decision-making.



NPHIs identify linkages with subnational health organizations as critical to their public health mission.

This underscores the important benefit of strong multilevel linkages. [32] NPHIs may also coordinate closely with networks of subnational public and private labs and facilities to support diagnostics, reference testing, and quality assurance.

NPHIs have created and enforced national standards and policies that subnational health authorities use (e.g., reporting diseases of public health concern). Further, many NPHIs create interoperable information systems to which subnational health systems contribute. [2,11,14,15]

NPHIs often support multilevel field epidemiology training or collaborate with research institutions at different levels of the health system to implement a national research agenda, such as through funding, joint priority-setting, and conferences. [21,22]

Enablers of Linkages between Central and Subnational Public Health Institutions

National legislation, policy, or joint strategies and work plans may support multilevel linkages.

Multilevel linkages often depend on the NPHI or other national authority that has a strong national system for the collection of data or coordination of subnational authorities. This may be supported by national legislation or policy, national strategies or work plans, or codified agreements such as memoranda of understanding (MOUs) and incident management structures (IMS). [16,33]

Engaging subnational entities in joint planning and agreements can aid in securing ownership and buy-in. NPHI leaders have reported that continuous advocacy helps maintain this buy-in. Close relationships built on trust, transparency, and bidirectional data sharing between national and subnational entities enable linkages. [24,34] Joint training levels and routine communication (e.g., working groups, annual meetings, email listservs) are also supportive.

Linkages in Action

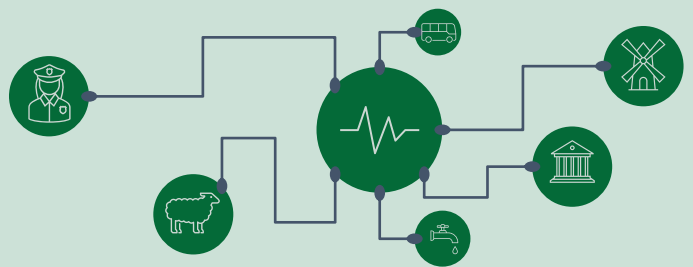
U.S. CDC routinely engages and supports local health departments during an outbreak response. For example, under the Zika Emergency Operations Center, the Pregnancy and Birth Defects Task Force established the Local Health Department Initiative (LHDI). As of January 2018, the LHDI seconded public health professionals to 28 health departments, engaging 2,464 clinical providers and testing 24,971 women for the disease across the United States' states and territories. [35]

During the COVID-19 pandemic, U.S. CDC created a dedicated response section to support state, tribal, local, and territorial health departments. It deployed 208 teams to support 55 subnational health departments with data collection, epidemiological investigations, contact tracing, and more. [36]

MULTISECTORAL LINKAGES

Linkages between NPHIs and Other Sectors

Multisectoral linkages are those between NPHIs and different sectors, including public, private, academic, and non-profit. Multisectoral linkages can also represent cross-disciplinary, all-hazards approaches. Linkages with other sectors ensure non-health actors understand the importance of public health, increase government coordination across sectors during all-hazard emergencies, expand the delivery of testing and health services, and help tackle complex health threats.



NPHIs often depend on collaboration with private-sector laboratories and civil society to reach special populations.

During public health emergencies, agencies for water, transport, energy, and security play vital roles. Outbreak response is often placed under an executive-level taskforce, where NPHIs may play a leadership role. To address complex all-hazards issues, such as climate change, NPHIs can assist in creating joint cross-sectoral goals, convene cross-sectoral staff, and conduct routine response communication between entities. [15] Combating emerging zoonotic diseases and AMR benefits from linkages between NPHIs and other health agencies with agencies representing animal and environmental health (i.e., *One Health*). [37]

NPHIs often depend on collaboration with private laboratories and health care facilities to expand access to services. Linkages with community-based organizations extend services to historically underserved populations. [15]

Enablers of Multisectoral Linkages

Joint training that facilitates shared nomenclature and clear intersectoral roles can accompany One Health roadmaps.

Enablers of multisectoral linkages are interorganizational in nature. Cross-sectoral strategies, such as national laboratory network plans, enable linkages with the private sector. Government policies that authorize emergency use of therapeutics from private-sector manufacturers also support linkages. [15]

National *One Health* platforms promote intersectoral collaboration through joint plans and routine convening of ministries of health, agriculture, and environment. Joint training to facilitate shared nomenclature and clear intersectoral roles can accompany roadmaps. [15]

Having predefined incident command structures and EOCs can further promote collaboration between sectors and agencies during emergencies or outbreaks. [38,39]

Linkages in Action

During COVID-19, Italy's NPHI participated in and/or led 20 multisectoral working groups that governed the nation's response. These working groups included organizations such as the ministry of health (MOH), statistics agency, academia, health departments, hospitals, and reference labs, who jointly established standards, tools, and policies related to health technologies, drugs and clinical trials, response training, and other topics. [40]

In Ukraine's COVID-19 response, the NPHI established a system whereby local autonomous laboratories could enter testing results into the national case registry system. Results were published on the Ministry of Digital Transformation's *Act at Home* self-isolation app, which enabled patients isolating at home to immediately access their results and make informed quarantine decisions. [41]

INTERNATIONAL LINKAGES

Linkages between NPHIs and International Entities

International linkages are actions that support collaboration between public health agencies and foreign governments, multilateral institutions, global associations, donors, and international private-sector suppliers. NPHIs have collaborated with other national governments in their region to plan for or manage outbreaks or disease threats that cross borders. [42] For example, NPHIs may work with neighboring countries on travel policies, contact tracing, or quarantine guidelines.



NPHIs have engaged in public-private partnerships focused on disease prevention campaigns.

NPHIs also collaborate with other governments to address the health needs of migrant or refugee populations. NPHIs in lower resource settings have forged working relationships with foreign governments and private donors, who provide external financial and technical assistance for disease control and population health programs. [15,23,43]

NPHIs routinely partner with or participate in multilateral institutions to support IHR, World Health Assembly resolutions, outbreak notification, and global data reporting. Inter-NPHI collaboration occurs via IANPHI or regional bodies such as the European CDC and Africa CDC. [26,44,45]

NPHIs may also engage international academic institutions or private-sector firms to conduct public health research, genomic sequencing, and clinical trials. Peer-to-peer linkages between individual NPHIs are facilitated by organizations such as IANPHI. [15]

Enablers of Linkages between NPHI and International Institutions

Countries may share public health assets such as regional reference labs or strategic stockpiles of vaccines, which enable cross-border collaboration.

Political support from national leaders is important for international partnerships. Inter-country agreements, MOUs, strategies, and policies further provide structure, common mission, and defined roles in international partnerships. Protocols such as international laboratory standards or agreements for biological specimen transport also support shared practices.

NPHIs may have a “partner liaison” or focal point for international partnerships (e.g., IHR) who is responsible for the relationship, representing the NPHI in joint planning and providing accountability for global or regional reporting.

Countries may further share public health assets such as regional reference labs, data platforms, or strategic stockpiles of vaccines or equipment, for more effective cross-border collaboration. [15]

Linkages in Action

The World Bank Regional Disease Surveillance Systems Enhancement (REDISSE) Program is an “interdependent series of projects” across 16 West and Central African nations. It encourages information sharing, policy alignment, joint planning, and asset sharing. Through REDISSE, 15 regional reference labs for human and animal health and a regional stockpile of personal protective equipment (PPE) and vaccines for epidemic response in Côte d'Ivoire were established. [45]

In Germany, Robert Koch Institute (RKI) conducts cross-border contact tracing. Authorized by the German Infection Prevention Act, the RKI is responsible for bidirectional communication regarding cases and case contacts with other European countries through the Early Warning and Response System for European Union countries and focal persons for IHR. [46]

Endnotes for Section II: Introducing Linkages

1. Kay, A.B. 1996. "The role of the laboratory in disease surveillance." *EMHJ-Eastern Mediterranean Health Journal*; 2:68–72. <https://apps.who.int/iris/handle/10665/118906>.
2. Carnevale, C., M. Woldetsadik, ... A.S.-H.P., et al. 2019. *Benefits and challenges of consolidating public health functions into a National Public Health Institute: a policy analysis*. researchgate.net Published Online First. doi:10.1093/heapol/czac102/6970047.
3. Dowell, S.F., J.W. Tappero, and T.R., Frieden. 2011. "Public Health in Haiti – Challenges and Progress." *New England Journal of Medicine*; 364:300–1. doi:10.1056/NEJMP1100118/SUPPL_FILE/NEJMP1100118_DISCLOSURES.PDF
4. Verrecchia, R., O. Dar, O. Mohamed-Ahmed, et al. 2019. "Building operational public health capacity through collaborative networks of National Public Health Institutes." *BMJ Glob Health*; 4:e001868. doi:10.1136/BMJGH-2019-001868.
5. Hsu, C.H., B. Harvey, A. Mohamed, et al. 2020. "Assessment of in-country capacity to maintain communicable disease surveillance and response services after polio eradication – Somalia." *Vaccine*; 38:1220–4. doi:10.1016/j.vaccine.2019.11.008.
6. Balabanova, Y., A. Gilsdorf, S. Buda, et al. 2011. "Communicable diseases prioritized for surveillance and epidemiological research: results of a standardized prioritization procedure in Germany, 2011." *PLoS One*; 6:e25691. doi:10.1371/journal.pone.0025691.
7. Nagbe, T., G.S. Williams, J.M. Rude, et al. 2019. "Lessons learned from detecting and responding to recurrent measles outbreak in Liberia post-Ebola Epidemic 2016–2017." *Pan Afr Med J*; 33:7. doi:10.11604/pamj.suppl.2019.33.2.17172.
8. Petersen, L.R., A. Ammon, O. Hamouda, et al. 2020. "Developing national epidemiologic capacity to meet the challenges of emerging infections in Germany." *Emerg Infect Dis*; 6:576–84.
9. International Association of National Public Health Institutes. 2007. "Framework for the creation and development of national public health institutes."
10. Lawson, B., K.J. Petersen, P.D. Cousins, et al. 2009. "Knowledge Sharing in Interorganizational Product Development Teams: The Effect of Formal and Informal Socialization Mechanisms." *Journal of Product Innovation Management*; 26:156–72. doi:10.1111/j.1540-5885.2009.00343.x.
11. Pinto, M.B., J.K. Pinto, and J.E. Prescott. 1993. "Antecedents and Consequences of Project Team Cross-Functional Cooperation." *Manage Sci*; 39:1281–97. doi:10.1287/mnsc.39.10.1281.
12. Frieden, T.R. and J.P. Koplan. 2010. "Stronger national public health institutes for global health." *The Lancet*; 376:1721–2. doi:10.1016/S0140-6736(10)62007-7.
13. Nguku, P., F. Moshia, E. Prentice, T. Galgalo, A. Olayinka, and P. Nsubuga. 2015. "Field Epidemiology and Laboratory Training Programs Have Been in Africa for 10 Years, What Is Their Effect on Laboratory-Based Surveillance? Reflections from a panel at the African Society of Laboratory Medicine December 2014 Cape Town meeting." *The Pan African medical journal*, 20, 451. <https://doi.org/10.11604/pamj.2015.20.451.6787>.
14. Varda, D., J.A. Shoup, and S. Miller. 2012. "A systematic review of collaboration and network research in the public affairs literature: Implications for public health practice and research." *Am J Public Health*; 102:564–71. doi:10.2105/AJPH.2011.300286.

Endnotes for Section II: Introducing Linkages

15. National Public Health Institutes Subject-Matter Experts. National Public Health Institutes, SME Consultations [Personal interviews, 2020].
16. Barzilay, E.J., H. Vandi, S. Binder, et al. 2018. "Use of the Staged Development Tool for Assessing, Planning, and Measuring Progress in the Development of National Public Health Institutes." *Health Secur*; 16:S18–24. doi:10.1089/hs.2018.0044.
17. IANPHI. 2019. "IANPHI - Revue par les pairs de Santé publique France."
18. Zuber, A., Y. Sebeh, D. Jarvis, et al. 2022. "Exploratory literature review of the role of national public health institutes in COVID-19 response." *Emerg Infect Dis*; 28:S151–8.
19. Deressa, W., P. Kayembe, A.H. Neel, et al. 2020. "Lessons learned from the polio eradication initiative in the Democratic Republic of Congo and Ethiopia: Analysis of implementation barriers and strategies." *BMC Public Health*; 20:1–15. doi:10.1186/S12889-020-09879-9/TABLES/3.
20. Martin, R. and I.S. Fall. 2021. "Field epidemiology training programs to accelerate public health workforce development and global health security." *Int J Infect Dis*; 110 Suppl 1:S3–5. doi:10.1016/J.IJID.2021.08.021
21. Task Force for Global Health. 2020. *Report on the Activities of the Field Epidemiology Training Program of Japan as a Contact Tracing Team on the National COVID-19 Response Team*. <https://www.tephinet.org/report-on-the-activities-of-the-field-epidemiology-training-program-of-japan-as-a-contact-tracing>.
22. Task Force for Global Health. 2020. *Field Notes from FETPs Fighting COVID-19: July 2020*. Accessed Aug 4, 2022. <https://www.tephinet.org/field-notes-from-fetps-fighting-covid-19-july-2020>.
23. Njidda, A.A.M., O. Oyebanji, J. Obasanya, et al. 2018. "The Nigeria Centre for Disease Control." *BMJ Glob Health*; 3:e000712. doi:10.1136/bmjgh-2018-000712.
24. Koplan, J.P., D. Butler-Jones, T. Tsang, et al. 2013. "Public health lessons from severe acute respiratory syndrome a decade later." *Emerg Infect Dis*; 19:861–3. doi:10.3201/eid1906.121426.
25. World Health Organization. n.d. *GOARN*. <https://goarn.who.int/>.
26. The International Association of National Public Health Institutes (IANPHI). n.d. *IANPHI members*. <https://ianphi.org/about/member-countries.html>.
27. Owens, M.D., M.L. Lloyd, T.M. Brady, et al. 2020. "Assessment of the Angolan (CHERRT) Mobile Laboratory Curriculum for Disaster and Pandemic Response." *Western Journal of Emergency Medicine*; 21:526.
28. Matrix Management: Not a Structure, a Frame of Mind: <https://hbr.org/1990/07/matrix-management-not-a-structure-a-frame-of-mind>.
29. Rauniar, R., W. Doll, G. Rawski, et al. 2008. "The role of heavyweight product manager in new product development." *International Journal of Operations & Production Management*; 28:130–54. doi:10.1108/01443570810846874.
30. Binder, S., L. Adigun, C. Dusenbury, et al. 2008. "National Public Health Institutes: contributing to the public good." *J Public Health Policy*; 29:3–21. doi:10.1057/PALGRAVE.JPHP.3200167.

Endnotes for Section II: Introducing Linkages

31. Global Health Center C. 2018. *Vietnam Tracks Multi-drug Resistant Bacteria*. <https://www.cdc.gov/globalhealth/security/stories/vietnam-tracks-multi-drug-resistant-bacteria.html>.
32. Nigeria Centre for Disease Control (NCDC) Leadership. National Public Health Institutes, SME Consultations [Personal interviews, March 2022].
33. World Health Organization. 2022. *Joint external evaluation tool: international health regulations*. Published Online First.. <https://apps.who.int/iris/bitstream/handle/10665/357087/9789240051980-eng.pdf?sequence=1>.
34. Binder, S. 2008. "NPHI creation: Lessons learned and future directions." *J Public Health Policy*; 29:459–66. doi:10.1057/jphp.2008.33.
35. National Center on Birth Defects and Developmental Disabilities. 2020. *Zika Local Health Department Initiative*. Accessed Aug 4, 2022. <https://www.cdc.gov/pregnancy/zika/research/lhdi.html>.
36. Dirlikov, E., E. Fechter-Leggett, S.L. Thorne, et al. 2020. "CDC deployments to state, tribal, local, and territorial health departments for COVID-19 emergency public health response – United States, January 21–July 25, 2020." *Morbidity and Mortality Weekly Report*; 69:1398.
37. National Center for Emerging and Zoonotic Infectious Diseases C. 2022. *One Health Basics*. <https://www.cdc.gov/onehealth/basics/index.html>.
38. EOCs. n.d. *eHealth Africa - Building stronger health systems in Africa*. Accessed Aug 4, 2022. <https://www.ehealthafrica.org/eocs>.
39. Shuaib, F.M., P.F. Musa, A. Muhammad, et al. 2017. "Containment of Ebola and Polio in Low-Resource Settings Using Principles and Practices of Emergency Operations Centers in Public Health." *J Public Health Manag Pract*; 23:3–10. doi:10.1097/PHH.0000000000000447.
40. Istituto Superiore di Sanità (ISS). 2021. *Notiziario, Special Issue: ISS for COVID-19*. https://www.iss.it/web/iss-en/notiziario/-/asset_publisher/ATfPbffqTz2N/content/id/5510001.
41. Ministry of Digital Transformation of Ukraine. 2020. "Act at Home" app is launched to counteract the spread of COVID-19 in Ukraine. Accessed Aug 4, 2022. <https://www.kmu.gov.ua/en/news/yak-pracyuye-zastosunok-dij-vdoma>.
42. Dente, M.G., M. Fabiani, R. Gnesotto, et al. 2009. "EpiSouth: A network for communicable disease control in the Mediterranean region and the Balkans." *Euro Surveill*; 14. doi:10.2807/ese.14.05.19113-en.
43. One Health Programme – Africa CDC. n.d. <https://africacdc.org/programme/surveillance-disease-intelligence/one-health/>
44. Africa CDC. 2019. *Providing a Legal Framework for a National Public Health Institute (NPHI)*. <https://africacdc.org/download/providing-a-legal-framework-for-a-national-public-health-institute-nphi/>.
45. The World Bank. 2020. *Epidemic Preparedness and Response, Results Brief*. <https://www.worldbank.org/en/results/2020/10/12/epidemic-preparedness-and-response>.
46. Markus, I., G. Steffen, R. Lachmann, et al. 2021. "COVID-19: cross-border contact tracing in Germany, February to April 2020." *Eurosurveillance*; 26:2001236.

SECTION III – DEVELOPING LINKAGES

Evidence-Based Enablers of Public Health Linkages

Enablers are processes, assets, and organizational characteristics

Research has shown that NPHIs and other organizations support enablers—processes, assets, and organizational characteristics—that can strengthen and bolster public health linkages. Those presented here are common enablers of linkages that were identified through reviews of public health and organizational development literature, as well as consultations with multiple NPHI leaders. This is not an exhaustive list; other enablers may be productive for a country context.

Policies, Agreements, and Legislation [1-5]

Examples:

- ✓ Legislative mandates
- ✓ Policies governing national–subnational relationships
- ✓ Rules and SOPs
- ✓ Data-sharing policies
- ✓ MOUs

Governance, Funding, and Resources [3,4,7,9,20-25]

Examples:

- ✓ Political support for linkages
- ✓ Funding and resources to support subnational activities
- ✓ Participation of subnational authorities in planning and implementation lifecycle
- ✓ Effective leadership and management of linkages
- ✓ Aligned or shared goals, strategic plans, and work plans



Infrastructure [3,6-19]

Examples:

- ✓ Physical structures for collaboration
- ✓ Public health observatories
- ✓ Information systems optimized for data sharing
- ✓ Conceptual or organizational frameworks for integration
- ✓ Regional public health assets

People and Organizational Culture [3,4,12,21,26-34]

Examples:

- ✓ Inclusivity of teams
- ✓ Trust
- ✓ Relationships and history of collaboration
- ✓ Effective internal communication
- ✓ Shared nomenclature
- ✓ Investing in skills and professional development
- ✓ Cross-functional collaboration mindset

Evidence-Based Enablers – Policies, Agreements, and Legislation

What are enablers related to policies, agreements, and legislation?

Policies and agreements can create standardization and predictability in the public health system. Establishing agreed-upon processes across essential public health functions and with other sectors and entities is a key tenet of preparedness, which promotes efficient collaboration. Further, policies, agreements, and legislation offer a channel for leaders to provide clarity for staff to implement linkages. The enablers below have been shown in research to support effective linkages. This list is not exhaustive.

Legislative mandates [3]

Obligate participation in public health activities, including linkages between national and subnational actors.

Example:

- ✓ Laws granting legal authority of national and subnational entities in public health, including clearly stipulated roles and accountability mechanisms

National-to-subnational policies [3,4]

Foster a shared understanding of joint activities and expectations for collaboration. Example:

- ✓ Policies with clear delineation of relationships and responsibilities between national/subnational actors

Data-sharing policies [3,4]

Ensure timely access to data for multiple users and provide for continuity of data sharing and knowledge management. Example:

- ✓ Policies defining expectations and standards for making data available to other functional teams and organizations



Rules and SOPs [4,5]

Offer teams predictability in procedures and decision-making and improve quality of collaboration by standardizing procedures based on evidence or best practice. Examples:

- ✓ SOPs, such as those provided in an incident management system, that establish common accountability and reporting practices and structures
- ✓ Rules for evaluation, control, and resolution of events or for guiding project teamwork

MOUs [3]

Encourage executive leadership's participation in forming and reinforcing linkages and further define organizational roles to meet legislative mandates. Example:

- ✓ Formalized commitments of actors to public health activities, including linkages

Evidence-Based Enablers – Infrastructure

What are enablers related to infrastructure?

Infrastructure can be physical or digital assets and resources NPHIs and their partners have created or have access to. Infrastructure can be as basic as an office two public health functions share or represent more sophisticated assets such as a national information system all facilities across the country use. Infrastructure enablers have been shown to provide a supportive environment for public health linkages. The enablers below have been shown in research to support effective linkages. This list is not exhaustive.

Regional public health assets [8]

Share costs of expensive health infrastructure across countries and expand regional response capacity and readiness. Example:

- ✓ Regional reference labs, joint partnerships with private or academic labs, strategic stockpiles, or other health infrastructure countries can access regionally

Public health observatories [3]

Enhance joint data access and analysis from different functional teams in MOH and other organizations. Examples:

- ✓ Physical or virtual venues for multisectoral actors to develop evidence-based public health policy
- ✓ Linking academic researchers to public health experts for development of policy or to inform health communications

Information systems optimized for data sharing [9–12]

Enable real-time data sharing among EPHFs and/or organizations, while also protecting data privacy through access roles. Example:

- ✓ Cloud-based, interoperable, and scalable platforms allowing users from different functions or agencies



Structures for proximity of staff [3,5,13–17]

Enable more frequent, in-person, informal collaboration and communication and can enhance shared affiliation, improve trust, and reduce siloes. Example:

- ✓ Physically co-locating staff representing teams from multiple public health functions in offices and/or buildings (e.g., NPHI campus, joint NPHI/MOH regional office, and Incident Command Center)

Conceptual or organizational frameworks for integration [3,13–19]

Bring stability, predictability, and permanence to cross-functional teams. Enable an improved understanding of how key functions relate and work together. Allow staff to consider the range of options and role choices available to managers who coordinate multisectoral networks. Examples:

- ✓ Incident management structures (e.g., EOCs, public health emergency operations centers [PHEOCs])
- ✓ Matrixed project teams or organizations
- ✓ Communities of practice or interagency working groups

Evidence-Based Enablers – Governance, Funding, and Resources

What are enablers related to governance, funding, and resources?

These enablers can create environments where linkages thrive. They include clear political or leadership priorities for collaboration, formal planning documents outlining linkage actions, and the accompanying resources that emphasize collaboration as the goal rather than competition. The enablers below have been shown in research to support effective linkages. This list is not exhaustive.

Political support [3,21]

Sends clear message to NPHI and other staff to support linkages as part of the public health mission and empowers the NPHI to lead and be held accountable for public health functions. Example:

- ✓ Formal decrees or evidence of senior political leadership's involvement in public health linkages

Funding and resources [4,9,21,22,23]

Establish predictability and continuity for linkages to thrive. Examples:

- ✓ Alignment of funding and resources with priorities determined by a concerted NPHI strategy rather than a political or historical rationale
- ✓ NPHI autonomy for resource mobilization
- ✓ Funding diversification and sharing of financial resources between functional teams or agencies

Subnational resources for public health [3]

Enable greater participation of subnational entities and staff in linkages and public health activities. Example:

- ✓ Specific funding or other resources for subnational public health activities



Effective leadership and management [3]

Establish the trust and partnership needed to effectively build linkages over time. Allow managers to navigate complexity to make sure linkages perform as intended. Examples:

- ✓ Leaders who set a clear vision and motivate staff to take on tasks and work together, even without a chain of command [3,21,24,28]
- ✓ Leaders who have the appropriate credibility and ability to influence [24]
- ✓ Designated project manager or champion who understands networked or matrix organizations/teams [25]

Shared goals and plans [4,5]

Surpass individual interests or incentives to compete [5] to enable linkages. Formalize shared commitments and enable monitoring and accountability for public health activities. Examples:

- ✓ National strategic plans to establish the common objectives, processes, activities, and outcomes that unify disparate teams and organizations
- ✓ Shared goals or work plans across teams or functions

Evidence-Based Enablers – People and Organizational Culture

What are enablers related to people and organizations?

These enablers include systems that allow for both communication and softer characteristics of relationships and trust, skills development, and staff mindsets that are developed over time to support effective cross-functional collaboration. The enablers below have been shown in research to support effective linkages. This list is not exhaustive.

Inclusivity of project teams [27]

Improves buy-in by all parties and ability of a team to relate and bring together different culture, vocabulary, and approaches of collaborating teams or organizations. Examples:

- ✓ Cross-functional teams include representatives from all functions or processes involved
- ✓ Teams include at least one “boundary spanner”—an individual who has strong knowledge of all the parts the linkage connects

Trust [4,21]

Enables collaboration with the NPHI when seen as a trusted partner and credible source of information. Example:

- ✓ The “degree of trust” between cross-functional team members affects collaboration and collaborative outcomes in a network structure

Relationships and history of joint work [3,4]

Establish working protocols and trust between partners before the need arises and reduce inefficiencies and misunderstandings. Example:

- ✓ Positive relationships and experiences working together that build strong social capital between organizations and teams, which can be drawn on in outbreaks or emergency

Effective communication and shared nomenclature [12]

Maintain routine communication and ensure messages are trusted; enable effective work between teams. Examples:

- ✓ Multiple (in)formal communication channels and feedback loops between teams with adequate resources
- ✓ Shared nomenclature of key terms
- ✓ Credible communications provided in a fair or transparent manner

Investing in skills and professional development [4,21,28,29]

Fosters understanding of the role of other functions and disciplines and builds skills to recognize opportunities for collaboration. Examples:

- ✓ Sustained investment in joint training of professionals from different disciplines, functions, and organizations
- ✓ Building skills to tackle cross-boundary problems and work effectively across matrix organizational structures

Systems thinking [30–34]

Builds trust and strong relationships between teams and allows simulation of outcomes of policies, programs, or actions between system elements. Example:

- ✓ Mindset that accounts for the interactions between systems elements



A Systematic Approach: Seven Steps NPHIs Can Follow to Implement Public Health Linkages and Enablers

Bringing a purposeful approach to linkages.

NPHI leaders in research report the need to be intentional about fostering linkages to realize their benefits. NPHIs may consider taking the following steps to increase the likelihood that linkages receive the commitment, investments, and promotion needed to be successful. Linkages are generally good organizational practice but may be more readily introduced as a solution targeting a priority organizational or public health challenge.

01 Secure Leadership Support

Presenting the need for a linkage assessment to decision-makers to secure support and establishing collaboration and trust

02 Understand the Current State

Mapping health systems actors and NPHI processes, consulting NPHI staff, and identifying and prioritizing gaps in public health linkages

03 Develop and Prioritize Solutions

Developing and prioritizing solutions to linkage gaps based on feasibility for change and impact on public health and use of resources

04 Formalize Planning

Engaging relevant parties to plan implementation of linkage solutions and incorporating priority linkages and enablers into strategic and operational plans

05 Support Linkages with Resources

Featuring linkages in government budgets and considering corporate, academic, foundation, or other co-investment

06 Implement Linkages and Enablers

Setting clear expectations for programs to incorporate linkages into interventions; providing training for management

07 Monitor, Evaluate, and Adapt

Monitoring and evaluating linkages initiatives, providing accountability for change, contributing to the evidence base, and adapting to challenges

LINKAGE OPPORTUNITIES FOR NATIONAL PUBLIC HEALTH INSTITUTES

Shining a spotlight on linkages reveals new approaches to strengthening responsiveness, resilience, and efficiency of public health systems, and equity of public health services.

This novel framework discusses potential interactions between (1) public health functions, (2) public health entities, and (3) health and non-health actors, which can improve the implementation of population health services. This shift in focus reveals a new terrain of opportunities to strengthen the delivery of public health functions and presents a chance to further cultivate and explore. Linkages are important considerations for NPHIs and others invested in the advancement of public health systems. Below are opportunities for countries to strengthen public health linkages.

- 1 Examining** current systems to see how strengthening the interactions between functions and organizations can improve efficiency and impact, even amid resource constraints.
- 2 Highlighting** robust interactions between functions and institutions that promote optimal public health impact over siloed or vertical capacity development.
- 3 Securing** political support at the highest levels to promote the formation of linkages and sustain that support over time.

LINKAGE OPPORTUNITIES FOR NATIONAL PUBLIC HEALTH INSTITUTES

Further research and consultation are needed to build on the existing evidence base and guide the development of linkages for public health impact.

- 4 Promoting** the mindset and skills for cross-functional, multi-disciplinary, and cross-sectoral collaboration among national public health and emergency workforces, which builds relationships, trust, communication, and other key enablers of linkages.
- 5 Monitoring and evaluating linkages** in health systems to identify gaps and raise visibility for successful models that can be shared and adapted in other settings.
- 6 Advancing** research on linkages and their enablers within NPHI research agendas, such as comparing models of linkages in different public health contexts or examining the trade-offs between consolidation and planned redundancy.
- 7 Furthering** connections between NPHIs through regional (e.g., Gulf CDC) and global platforms (e.g., IANPHI) and communities of practice to share leading best practices and solve public health problems with collective action.

Endnotes for Section III: Developing Linkages

1. National Center on Birth Defects and Developmental Disabilities. 2020. *Zika Local Health Department Initiative*. Accessed Aug 4, 2022. <https://www.cdc.gov/pregnancy/zika/research/lhdi.html>.
2. Dowell, S.F., J.W. Tappero, and T.R. Frieden. 2011. "Public Health in Haiti — Challenges and Progress." *New England Journal of Medicine*; 364:300–1. doi:10.1056/NEJMP1100118/SUPPL_FILE/NEJMP1100118_DISCLOSURES.PDF.
3. National Public Health Institutes Subject-Matter Experts. National Public Health Institutes, SME Consultations [Personal interviews, 2020].
4. Varda, D., J.A. Shoup, and S. Miller. 2012. "A systematic review of collaboration and network research in the public affairs literature: Implications for public health practice and research." *Am J Public Health*; 102:564–71. doi:10.2105/AJPH.2011.300286.
5. Pinto, M.B., J.K. Pinto, and J.E. Prescott. 1993. "Antecedents and Consequences of Project Team Cross-Functional Cooperation." *Manage Sci*; 39:1281–97. doi:10.1287/mnsc.39.10.1281.
6. Dirlikov, E., E. Fechter-Leggett, S.L. Thorne, et al. 2020. "CDC deployments to state, tribal, local, and territorial health departments for COVID-19 emergency public health response – United States, January 21–July 25, 2020." *Morbidity and Mortality Weekly Report*; 69:1398.
7. Instituto Nacional de Salud. 2020. *Implementación del sistema de información para la vigilancia por laboratorio - SIVILAB*. Accessed Aug 8, 2021. <https://www.ins.gov.co/BibliotecaDigital/comunicado-implementacion-sivilab-2020-11-04.pdf#search=SIVILAB>.
8. The World Bank. 2020. *Epidemic Preparedness and Response, results brief*. Accessed Jun 7, 2023. <https://www.worldbank.org/en/results/2020/10/12/epidemic-preparedness-and-response>.
9. Radnor, Z. and J. Robinson. 2000. "Benchmarking Innovation: A Short Report." *Creativity & Innovation Management*; 9:3. doi:10.1111/1467-8691.00153.
10. Barczak, G., A. Griffin, and K.B. Kahn. 2009. "PERSPECTIVE: Trends and Drivers of Success in NPD Practices: Results of the 2003 PDMA Best Practices Study." *Journal of Product Innovation Management*; 26:3–23. doi:10.1111/j.1540-5885.2009.00331.x.
11. Terziovski, M., A. Sohal, and A. Howell. 2022. "Best practice in product innovation at Varian Australia." *Technovation*; 22:561. doi:10.1016/S0166-4972(01)00060-8.
12. Dyer, J. 2004. "Cross-functional teams." *Chartered Accountants Journal*; 83:63–4. <https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,shib&db=bth&AN=12915535&site=ehost-live&scope=site&custid=gsu1>.
13. Petersen, L.R., A. Ammon, O. Hamouda, et al. 2000. "Developing national epidemiologic capacity to meet the challenges of emerging infections in Germany." *Emerg Infect Dis*; 6:576–84. doi:10.3201/eid0606.000605.

Endnotes for Section III: Developing Linkages

14. CDC. 2016. "Zambia: Learning from Cholera Outbreak to Build a Stronger Public Health Institute."
15. Njidda, A.A.M., O. Oyebanji, J. Obasanya, et al. 2018. "The Nigeria Centre for Disease Control." *BMJ Glob Health*; 3:e000712. doi:10.1136/bmjgh-2018-000712.
16. IANPHI. 2015. "The National Institute for Public Health and the Environment (RIVM)."
17. IANPHI. 2019. "IANPHI - Revue par les pairs de santé publique France."
18. Harvard Business Review. 1990. *Matrix Management: Not a Structure, a Frame of Mind*. Accessed Jun 7, 2023. <https://hbr.org/1990/07/matrix-management-not-a-structure-a-frame-of-mind>.
19. Ford, R.C. and W.A. Randolph. 1992. "Cross-Functional Structures: A Review and Integration of Matrix Organization and Project Management." *J Manage*; 18:267–94. doi:10.1177/014920639201800204.
20. Division of Global Health Protection. 2018. *NPHI Investments Helped Colombia Prepare for Zika*. Accessed Aug 8, 29021. <https://www.cdc.gov/globalhealth/healthprotection/fieldupdates/fall-2016/colombia-nphi-zika.html>.
21. Binder, S. 2008. "NPHI creation: Lessons learned and future directions." *J Public Health Policy*; 29:459–66. doi:10.1057/jphp.2008.33.
22. Marion, T.J., J.H. Friar, and T.W. Simpson. "New Product Development Practices and Early-Stage Firms: Two In-Depth Case Studies." *Journal of Product Innovation Management*.
23. Verrecchia, R., O. Dar, O. Mohamed-Ahmed, et al. 2019. "Building operational public health capacity through collaborative networks of National Public Health Institutes." *BMJ Glob Health*; 4:e001868. doi:10.1136/BMJGH-2019-001868.
24. Rauniar, R., W. Doll, G. Rawski, et al. 2008. "The role of heavyweight product manager in new product development." *International Journal of Operations & Production Management*; 28:130–54. doi:10.1108/01443570810846874.
25. Dutta, D. and I. Bose. 2015. "Managing a Big Data Project: The case of Ramco Cements Limited." *Int J Prod Econ*; 165:293–306. doi:10.1016/j.ijpe.2014.12.032.
26. Markus, I., G. Steffen, R. Lachmann, et al. 2021. "COVID-19: Cross-border contact tracing in Germany, February to April 2020." *Eurosurveillance*; 26. doi:10.2807/1560-7917.ES.2021.26.10.2001236.
27. World Health Organization. Regional Office for the Western Pacific, WHO. 2003. "Essential public health functions: A three-country study in the Western Pacific Region." WHO Regional Office for the Western Pacific.
28. Bjegović-Mikanović, V., M. Santrić-Miličević, A. Cichowska, et al. 2018. "Sustaining success: Aligning the public health workforce in South-Eastern Europe with strategic public health priorities." *Int J Public Health*; 63:651–62. doi:10.1007/s00038-018-1105-7.

Endnotes for Section III: Developing Linkages

29. Gray, S.F. and D. Evans. 2018. "Developing the public health workforce: Training and recognizing specialists in public health from backgrounds other than medicine: Experience in the UK." *Public Health Rev*; 39. doi:10.1186/s40985-018-0091-x.
30. Allan, B. and S. Jessie. 2012. "Complexity and Lessons Learned from the Health Sector for Country System Strengthening."
31. Mutale, W., D. Balabanova, N. Chintu, et al. 2016. "Application of system thinking concepts in health system strengthening in low-income settings: A proposed conceptual framework for the evaluation of a complex health system intervention: The case of the BHOMA intervention in Zambia." *J Eval Clin Pract*; 22:112–21. doi:10.1111/jep.12160.
28. USAID. 2017. "Spaces Systems Map of the Ugandan Health System."
29. Atun, R. 2012. *Health systems, systems thinking and innovation*. pdfs.semanticscholar.org. Published Online First: 2012. doi:10.1093/heapol/czs088.
30. Rosenfeld, E.L., S. Binder, C.A. Brush, et al. 2020. "National Public Health Institute Legal Framework: A Tool to Build Public Health Capacity." *Health Secur*;18:S43–52. doi:10.1089/hs.2019.0093.
31. Rauniar, R., W. Doll, G. Rawski, et al. 2008. "The role of heavyweight product manager in new product development." *International Journal of Operations & Production Management*; 28:130–54. doi:10.1108/01443570810846874.
32. Marion, T.J., J.H. Friar, and T.W. Simpson. 2012. "New Product Development Practices and Early-Stage Firms: Two In-Depth Case Studies." *Journal of Product Innovation Management*; 29:639–54. doi:10.1111/j.1540-5885.2012.00930.x.
33. Dutta, D. and I. Bose. 2015. "Managing a Big Data Project: The case of Ramco Cements Limited." *Int J Prod Econ*; 165:293–306. doi:10.1016/j.ijpe.2014.12.032.
34. Verrecchia, R., O. Dar, O. Mohamed-Ahmed, et al. 2019. "Building operational public health capacity through collaborative networks of National Public Health Institutes." *BMJ Glob Health*; 4:e001868. doi:10.1136/BMJGH-2019-001868.

SECTION IV – APPENDICES

APPENDIX A – COUNTRY CASE STUDIES

Georgia, Nigeria, and South Korea

CASE STUDY I

MULTIFUNCTIONAL LINKAGES IN ACTION

THE GEORGIA HEPATITIS C ELIMINATION PROGRAM ^[1]



Background

Georgia's National Center for Disease Control and Public Health (NCDC) has roots in Georgia's Anti-plague Station, founded in 1937. After undergoing multiple iterations, it was established in its current form under the 2003 health reform. In 2015, Georgia faced one of the highest burdens of hepatitis C (HCV) in the world. The Government of Georgia, with support from U.S. CDC and a pharmaceutical partner, set an ambitious aim—to reduce HCV by 90 percent. The Ministry of Internally Displaced Persons from the Occupied Territories, Labour, Health, and Social Affairs (MoH) and NCDC embedded multifunctional linkages into their HCV elimination strategy. The approach reflected local context, where the private sector provides 90 percent of health services, including laboratory services.

Multilateral Linkages for HCV

Surveillance, laboratory, and clinical data combined in one database with unique patient identifiers for population-level tracking of cases from suspected to confirmed infections and to help providers in connecting patients to treatment.

Health promotion campaign with public/private primary care providers, local government, and existing civil society harm-reduction networks.

Laboratory diagnostic services from public and private laboratories—reimbursed through the MoH National Health Agency—with NCDC conducting quality control and proficiency testing.

Public health research coordinated by a Scientific Committee co-chaired by NCDC and U.S. CDC, which has approved more than 80 research proposals to inform program delivery.

CASE STUDY I

MULTIFUNCTIONAL LINKAGES IN ACTION

THE GEORGIA HEPATITIS C ELIMINATION PROGRAM

“Linkages enabled the HCV elimination program to work more effectively and achieve clear, measurable health outcomes for the most vulnerable in our nation.”

– Dr. Amiran Gamkrelidze
Director General, NCDC Georgia

Workforce development supported through continuing education and clinical guidelines for management of HCV infection, including disbursement of funds and contracts, managing the integrated surveillance data, and coordinating the working groups and partners

NCDC hosts annual multi-stakeholder workshops to review progress and set priorities. Georgia provided its HCV data to Bristol University to inform disease modeling used to support resource decisions. Additionally supporting program monitoring are multidisciplinary district teams from local public health centers, government, and private health care services.

The program responds in a timely manner to emerging challenges. Recognizing testing costs as a barrier to elimination, the government began providing free serology and confirmatory HCV testing in 2015. This cost was covered by funding approved by Georgia’s parliament.

Impact of Linkages and the HCV Elimination Program

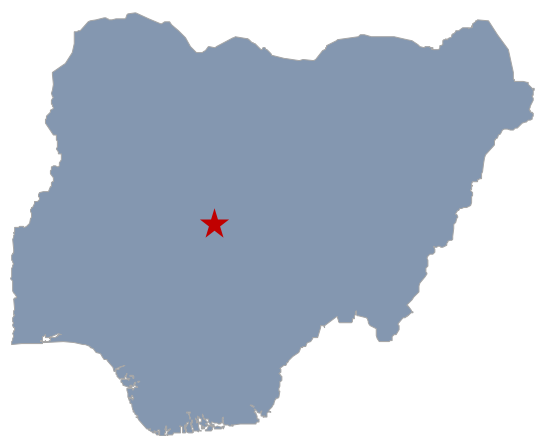
Georgia pursued an inclusive approach to the program, leveraging existing services and incorporating multiple EPHFs for impact. By 2021, approximately 80 percent of the adult population had been screened and over 77,000 people successfully treated. Prevalence of active infection (via PCR test) dropped from 5.4 to 1.8 percent in 2015 and 2021, respectively. Among people who inject drugs, chronic HCV infection declined from 51.1 to 17.8 percent. By 2021, integrated HIV/TB/HCV screening had been expanded to 1,044 sites.

In 2019, Georgia was the first country to be named as a Centre of Excellence in Viral Hepatitis Elimination by the International Liver Congress, and in 2021, Georgia received the U.S. CDC’s highest level of recognition, the Honor Award, for its work to eliminate HCV.

CASE STUDY II

MULTILEVEL LINKAGES IN ACTION

COVID-19 AND EBOLA VIRUS DISEASE RESPONSE IN NIGERIA ^[2]



Background

The Nigeria Centre for Disease Control (Nigeria CDC) was formed in 2011, through consolidation of the Epidemiology Division, the Central Public Health Laboratory, and the Avian Influenza Program of the Federal Ministry of Health under one institution. The Nigeria CDC has played a pivotal role in the control of many infectious disease outbreaks, including Ebola virus disease (EVD) and COVID-19. The Nigeria Constitution states that health is an area of shared responsibility between national and state authorities. In this context, the Nigeria CDC has adopted a strong set of linkages to capacitate and coordinate subnational actors in the pursuit of emergency response and management.

Multilevel Linkages

Directorate of Subnational Support. A unit created by Nigeria CDC to support public health activities at state and local government levels.

Network of state-based PHEOCs. Nigeria CDC provides training, equipment, and guidance to states in their development of PHEOCs and supports coordination under the national PHEOC.

Workforce development. Nigeria CDC deploys epidemiologists to states, provides continuous training of state staff, and includes states in simulation exercises; Many state health authorities graduated from Nigeria CDC's field epidemiology and laboratory training programs.

Thematic working groups. Nigeria CDC leads disease-specific working groups that bring together national and subnational actors to advance coordination and knowledge sharing.

Surveillance Outbreak Response Management and Analysis System (SORMAS). Nigeria CDC's integrated bio-surveillance platform that generates data in real time from subnational authorities to detect and control outbreaks.

CASE STUDY II

MULTILEVEL LINKAGES IN ACTION

COVID-19 AND EVD RESPONSE IN NIGERIA

Nigeria CDC has a new subnational support department to foster close collaboration and decision-making, sharing of data, and capacity building for improved emergency response at state and local levels.

Enablers

Nigeria CDC attributes its successes to several of the key enablers identified in this framework:

- Strong political commitment in the form of ownership and funding from the Nigerian government, especially at the national level
- Policies that ensure that agreements at the National Council on Health are binding on states
- Continuous training of state health staff to address turnover and emerging skills needs
- Close working relationships between Nigeria CDC and state health staff
- Continuous advocacy with governors and other state entities to sustain support
- Real-time data-sharing practices using a disease outbreak surveillance system via SORMAS, with controls for access and ethics review
- WHO's joint external evaluation (JEE) as a shared vision for capacity gaps and priority actions

How Linkages Were Developed

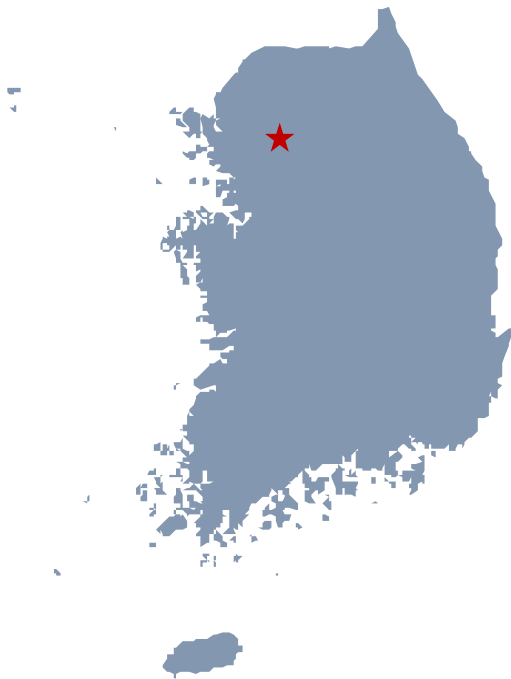
Before the 2014 EVD outbreak, the FMOH managed multilevel linkages with state authorities. Nigeria CDC's role grew over time, beginning with building and strengthening the integrated disease surveillance and response strategy. In 2017, Nigeria implemented a JEE at the national level, and Nigeria CDC was assigned to address gaps in health security infrastructure.

Nigeria CDC further deployed the JEE in select states and became responsible for supporting state-level capacity needs. One of Nigeria CDC's first activities was conducting advocacy with governors and other state authorities to establish state-based PHEOCs. Nigeria CDC provides guidance on their formation and staffing, procures equipment and supplies, and delivers continuous training of staff.

CASE STUDY III

MULTISECTORAL LINKAGES

SOUTH KOREA COVID-19 RESPONSE ^[3]



Background

The Korea Disease Control and Prevention Agency (KDCA) is the keystone of the current infectious disease control and management system of South Korea. It was created after the 2003 SARS epidemic as a result of the restructuring of the former National Institute of Health. In 2015, after the outbreak of Middle Eastern Respiratory Syndrome (MERS), the Korea Centers for Disease Control and Prevention head was promoted to a vice-ministerial position. In 2020, the centers were given “agency” status with autonomy and resources, becoming the KDCA.

KDCA plays a pivotal national leadership role in the COVID-19 response. Among its interventions, KDCA conducted important multisectoral collaboration with private laboratories to make early testing widely available, providing an exemplary epidemic control model in 2020–2021.

Multisectoral Linkages

Convening manufacturers. KDCA used its convening power to bring in-vitro diagnostic manufacturers together shortly after the first COVID-19 case was diagnosed to encourage the production of COVID-19 tests for national use

Public–private integrated network. KDCA brought private medical laboratories, hospital laboratories, and public-sector laboratories into an integrated network and provided training, supplies, quality assurance, and guidance

Pan-government support group: This multi-agency effort provided research and development support and biosafety facilities to the private sector for COVID-19 treatment and vaccine trials

Research consultation body: Government and private-sector research institutes collaborate to provide guidance on research and development of COVID-19 treatment and vaccines

CASE STUDY III

MULTISECTORAL LINKAGES

SOUTH KOREA COVID-19 RESPONSE

“Building a sustainable national laboratory system with public and private collaboration is important for nascent and established NPHIs worldwide.”

– **Dr. Gab Jung KIM**

Director of the Laboratory Diagnostics Management Division, KDCA

After the first cases of COVID-19 were identified, KDCA convened government research institutes to discuss how to support private-sector partnerships for diagnostic, therapeutic, and vaccine development. One key decision was to share select government laboratories with private-sector manufacturers. Another key step was for KDCA to assemble in-vitro diagnostic manufacturers and encourage them to develop test kits using the KDCA testing method for the national response.

Together with the Korean Society for Laboratory Medicine, KDCA provided clinical evaluation of all tests and submitted documentation for private-sector applications to the Ministry of Food and Drug Safety. KDCA issued an emergency use authorization to speed up the development and increase the supply of diagnostics equipment.

KDCA designated volunteer private medical laboratories, including those within hospitals, to join an integrated public–private laboratory network. KDCA then supplied guidelines for accurate testing, training, and quality assessment.

Impact of Linkages

KDCA leaders report that the multisectoral linkages with private laboratories and in-vitro diagnostic manufacturers have:

- Enabled rapid proliferation of COVID-19 tests nationwide, allowing for early detection and contact tracing
- Supported conduct of 170 million COVID-19 tests through the laboratory network
- Allowed South Korea, through early detection and control, to keep COVID-19 transmission throughout 2020 and 2021 at much lower levels than many comparable countries



Endnotes for Appendix A: Country Case Studies

1. Georgia National Center for Disease Control and Public Health (NCDC) Leadership. National Public Health Institutes, SME Consultations [Personal interviews, February 2022].
2. Nigeria Centre for Disease Control (NCDC) Leadership. National Public Health Institutes, SME Consultations [Personal interviews, March 2022].
3. Korea Disease Control and Prevention Agency (KDCA) Leadership. National Public Health Institutes, SME Consultations [Personal interviews, June 2022].

APPENDIX B – FUNCTIONAL LINKAGE REFERENCE TABLES



LABORATORY SERVICES LINKAGES TO OTHER FUNCTIONS

Overview of Laboratory Services

IANPHI incorporates laboratory services into “Core Function 2: Public health surveillance, problem investigation, and control of risks and threats to public health.” It includes diagnosis of pathogens, virus genotyping, and serologic testing to support estimation of disease prevalence, and testing to support vaccine and therapeutic pharmaceutical development.

Surveillance



- ✓ Lab data team that analyzes anomalies and provides information to the epidemiology team
- ✓ Routine communications between lab and surveillance teams
- ✓ Common laboratory–epidemiology data-sharing platform, nomenclature, and SOPs
- ✓ Establishing vector-borne, sentinel, and population surveillance methods

Outbreak Response



- ✓ Joint response plan to manage lab samples and data
- ✓ Surge capacity among labs for future outbreaks
- ✓ Shared reporting system between lab and surveillance teams for infectious diseases
- ✓ Procedures and a platform for sharing lab data for outbreak response
- ✓ Lab database team to manage data and establish thresholds for outbreak determination

Workforce Development



- ✓ Supporting NPHI staff to attend lab degree programs
- ✓ Training of lab staff in procedures and lab management
- ✓ SOPs for lab services
- ✓ Lab staffing plans

Emergency Management



- ✓ Governance structure that can be activated for outbreak response and emergency management
- ✓ Continuous improvement approaches for outbreak response and emergency management

Health Promotion



- ✓ Risk communications between lab and communications staff
- ✓ Sentinel sites or public observatories to connect lab and surveillance data with health promotion messages
- ✓ Sharing lab data on specimen genotypes and trends for targeted public health messaging

Research



- ✓ Research to facilitate learning from outbreaks
- ✓ Research on therapeutics and vaccine trials to inform outbreak response



WORKFORCE DEVELOPMENT LINKAGES TO OTHER FUNCTIONS

Overview of Workforce Development

IANPHI notes NPHIs have the responsibility to “develop a public health workforce that is adequate for national needs, both for the NPHI itself and to support the broader public health infrastructure.” Activities include providing education and training, ensuring appropriate workforce size, creating partnerships with academia, and fostering public health leadership. Below are illustrative linkages between workforce development and other functions.

Surveillance



- ✓ Surveillance networks
- ✓ Shared surveillance nomenclature and SOPs
- ✓ Surveillance staff plans
- ✓ Training of surveillance and epidemiology staff (e.g., FETP-Frontline)
- ✓ Analysis of surveillance data by fellows

Emergency Management



- ✓ SOPs for emergency management
- ✓ Co-location of staff through EOCs
- ✓ Clear position descriptions and scheme of service
- ✓ Knowledge management
- ✓ Training in emergency management

Laboratory Services



- ✓ Supporting NPHI staff to attend lab degree programs
- ✓ Training of lab staff in procedures and lab management
- ✓ SOPs for lab services
- ✓ Lab staffing plans

Outbreak Response



- ✓ Degrees in epidemiology, laboratory, and informatics
- ✓ Workforce planning
- ✓ Field epidemiology training (e.g., FETP)
- ✓ Using RRTs to build local capacity

Health Promotion



- ✓ Training staff in risk communication, community outreach, and health screening
- ✓ Epidemiologic bulletins

Research



- ✓ Research on the public health workforce
- ✓ Performance assessments
- ✓ Developing research capacity of NPHI staff



PUBLIC HEALTH RESEARCH LINKAGES TO OTHER FUNCTIONS

Overview of Public Health Research

Public health research is a core function that characterizes the most important health issues in the country, produces data essential for decision-making, and evaluates interventions. IANPHI notes NPHIs “should focus their research on high priorities, particularly those that are not being addressed by universities or other research institutions.” Below are illustrative linkages between public health research and other functions.

Surveillance



- ✓ Sharing surveillance data for research
- ✓ Producing research to explain surveillance data or fill gaps (e.g., vulnerable populations)
- ✓ Using surveillance data to inform research priorities
- ✓ Evaluating surveillance systems

Laboratory Services



- ✓ Sharing lab data with researchers
- ✓ Building capacity in research among laboratory staff
- ✓ Establishing working groups to define research priorities and methods
- ✓ Conducting implementation science to improve lab services

Outbreak Response



- ✓ Conducting research to facilitate learning (e.g., outbreak after action reviews)
- ✓ Conducting research on therapeutics and vaccine trials to inform outbreak response

Emergency Management



- ✓ Conducting research that facilitates learning from emergency response efforts (e.g., after-action reviews)
- ✓ Conducting research on emergency preparedness
- ✓ Evaluating emergency preparedness capacity

Health Promotion



- ✓ Using applied research and special studies to understand vulnerable populations
- ✓ Evaluating impact of behavioral approaches on disease prevention
- ✓ Promoting epidemiologic studies that inform culturally appropriate health promotion interventions

Workforce Development



- ✓ Conducting research on the public health workforce
- ✓ Performance assessments
- ✓ Developing research capacity of NPHI staff



PUBLIC HEALTH SURVEILLANCE LINKAGES TO OTHER FUNCTIONS

Overview of Public Health Surveillance

IANPHI defines surveillance as “ongoing systematic collection, analysis, interpretation of health data, and dissemination of the results, with the goal of using the data to guide public health action.” It includes the ongoing monitoring for outbreaks and other public health problems. Its activities entail developing health indicators, routine collection and analysis of data, and production of periodic reports to disseminate information. Below are illustrative linkages between public health surveillance other functions.

Workforce Development



- ✓ Surveillance networks
- ✓ Shared surveillance nomenclature and SOPs
- ✓ Surveillance staffing plans
- ✓ Training of surveillance and epidemiology staff (e.g., FETP)
- ✓ Analysis of surveillance data

Laboratory Services



- ✓ Lab data team that analyzes surveillance data for anomalies
- ✓ Routine communications between laboratory and surveillance teams
- ✓ Common laboratory–epidemiology data-sharing platform, nomenclature, and SOPs
- ✓ Establishing vector-borne, sentinel, and demographic surveillance methods

Health Promotion



- ✓ Epidemiological bulletin
- ✓ Websites for users to access surveillance data
- ✓ Working groups to perform risk assessment and risk communication daily
- ✓ Sharing surveillance data for health promotion activities
- ✓ Sharing data with municipalities for health messaging and contact tracing

Emergency Management



- ✓ Sharing surveillance data to identify at-risk populations and establish notifiable disease lists
- ✓ Projecting epidemiologic curves to determine outbreaks of international concern
- ✓ Using surveillance data to set triggers for activation of EOCs
- ✓ Simulation exercises

Outbreak Response



- ✓ Using surveillance data to produce routine and custom reports on outbreaks
- ✓ Organizing data review meetings between surveillance and response teams
- ✓ Establishing response SOPs
- ✓ Including the surveillance team in collection and analysis of data and outbreak investigation

Research



- ✓ Sharing surveillance data for research
- ✓ Research to explain surveillance data or fill gaps (e.g., vulnerable populations)
- ✓ Using surveillance data to inform research priorities
- ✓ Evaluating surveillance systems



OUTBREAK RESPONSE LINKAGES TO OTHER FUNCTIONS

Overview of Outbreak Response

IANPHI incorporates the public health outbreak response into its second core function: “Public health surveillance, problem investigation, and control of risks and threats to public health.” Activities include investigating outbreaks or threats and making sure that interventions are put in place to address them. It is the result of ongoing surveillance and monitoring of outbreaks. Below are illustrative examples of linkages with outbreak response and other functions.

Surveillance



- ✓ Using surveillance data to produce routine and custom reports on outbreaks
- ✓ Hosting data review meetings between surveillance and response teams
- ✓ Setting up SOPs
- ✓ Including the surveillance team in collection and analysis of data and outbreak investigation

Laboratory Services



- ✓ Joint strategic response plan to manage lab samples and data
- ✓ Ensuring lab surge capacity for future outbreaks
- ✓ Shared reporting system between lab and surveillance teams for infectious diseases
- ✓ Procedures and a platform to share lab data for outbreak response
- ✓ Lab database team to manage data and establish thresholds for outbreak determination

Research



- ✓ Conducting research that facilitates learning from outbreaks
- ✓ Conducting research on therapeutics and vaccine trials to inform outbreak response

Emergency Management



- ✓ Governance structure that can be activated for outbreak response and emergency management
- ✓ Continuous quality improvement approaches for outbreak response and emergency management

Health Promotion



- ✓ Formulating risk communication
- ✓ Working group to identify policies/procedures and engaged communities
- ✓ Training health promotions staff in emergency management
- ✓ Maintaining a network of community partners that can be mobilized during an outbreak

Workforce Development



- ✓ Supporting NPHI staff to achieve degrees in epidemiology, laboratory, and informatics
- ✓ Long-term workforce planning
- ✓ Field epidemiology training
- ✓ Using RRTs to build local capacity



PUBLIC HEALTH PROMOTION LINKAGES TO OTHER FUNCTIONS

Overview of Public Health Promotion

IANPHI incorporates this function into its "Core Function 3: Prevention programs and health promotion." Activities involve taking action to create the conditions that promote health in the population, and include disease prevention programming (e.g., vaccination) and informing and educating people about how to improve their health. Below are illustrative linkages between public health promotion and other functions.

Workforce Development



- ✓ Training in public health communications, including risk communication
- ✓ Producing an epidemiologic bulletin
- ✓ Training health workers in community outreach and health screening

Laboratory Services



- ✓ Engagement between lab and communications staff for risk communication
- ✓ Sentinel sites or public observatories to connect lab surveillance data with health promotion messages
- ✓ Sharing lab data on specimen genotypes and trends for targeted health messaging

Outbreak Response



- ✓ Formulating risk communication
- ✓ Working group to identify policies/procedures and engaged communities
- ✓ Training health promotions staff in emergency management
- ✓ Maintaining a network of community partners that can be mobilized during an outbreak

Emergency Management



- ✓ Conducting risk communication
- ✓ Establishing working groups to identify policies and SOPs for health communications
- ✓ Health promotion team's participation in response

Surveillance



- ✓ Working groups to identify policies and procedures for health communications and community engagement during outbreaks
- ✓ Training health promotion staff in emergency mgt
- ✓ Network of community partners that can be mobilized during an outbreak
- ✓ Formulating risk communication
- ✓ Working group to identify policies and procedures

Research



- ✓ Using applied research and special studies to understand vulnerable populations
- ✓ Evaluating impact of behavioral approaches on disease prevention
- ✓ Promoting epidemiologic studies that inform culturally appropriate health promotion interventions



EMERGENCY MANAGEMENT LINKAGES TO OTHER FUNCTIONS

Overview of Emergency Management

IANPHI notes NPHI are “an integral part of the government’s planning for and response to emergencies and disasters.” The emergency management function determines in advance what services the NPHI will provide in an emergency and supplies materials and training to ensure smooth functioning during a nation’s response to an emergency. Below are illustrative examples of linkages between emergency management and other functions.

Surveillance



- ✓ Sharing surveillance data to identify at-risk populations and establish notifiable disease lists
- ✓ Projecting epidemiologic curves to determine outbreaks of international concern
- ✓ Using surveillance data to establish triggers for activation of EOCs
- ✓ Simulation exercises

Laboratory Services



- ✓ Routine communications between laboratory and emergency staff for timely decision-making
- ✓ Monitoring of therapeutics in emergency management
- ✓ Planning for lab surge capacity in emergencies
- ✓ Providing lab data on notifiable conditions

Research



- ✓ Conducting research that facilitates learning from emergency response efforts (e.g., after-action reviews)
- ✓ Conducting research on emergency preparedness
- ✓ Evaluating emergency preparedness capacity

Outbreak Response



- ✓ Governance structure that can be activated for outbreak response and emergency management
- ✓ Continuous quality improvement approaches for outbreak response and emergency management

Workforce Development



- ✓ SOPs for emergency management
- ✓ Co-location of EOC staff
- ✓ Clear position descriptions and scheme of service
- ✓ Knowledge management
- ✓ Training in emergency management

Health Promotion



- ✓ Conducting risk communication
- ✓ Establishing working groups to identify policies and SOPs for health communications
- ✓ Participating in response (health promotion team)



The United States Centers for Disease Control and Prevention

www.cdc.gov

For more than 70 years, U.S. CDC has put science into action to help children stay healthy so they can grow and learn; to help families, businesses, and communities fight disease; and to protect the public's health and promote health equity, in the U.S. and worldwide. U.S. CDC envisions a world in which everyone can achieve the highest attainable level of health, and no one is disadvantaged from achieving this potential because of social position or any other social, economic, demographic, or geographic circumstance or physical condition.

info@cdc.gov 

facebook.com/cdc 

[@CDCGlobal](https://twitter.com/CDCGlobal) 

[@CDCStreamingHealth](https://www.youtube.com/channel/UCvD910e89053696117gBa3w) 