

Essential public health functions are not enough: fostering linkages between functions through National Public Health Institutes improves public health impact

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ABSTRACT

COVID-19 has highlighted the importance of essential public health functions (EPHFs) and the coordination between them. The US Centers for Disease Control and Prevention defines EPHFs as ‘the public health activities that all communities should undertake’. According to multiple functional frameworks published in literature, the functions typically include workforce development, surveillance, public health research, laboratory services, health promotion, outbreak response and emergency management. National Public Health Institutes (NPHIs) are often the lead government agency responsible for execution of these functions. This paper describes how NPHIs or other health authorities can improve public health impact by enhancing the coordination of public health functions and public health actors through functional and organisational linkages. We define public health linkages as practical, replicable activities that facilitate collaboration between public health functions or organisations to improve public health. In this paper, we propose a novel typology to categorise important public health linkages and describe enablers of linkages identified through our research.

Based on our research, investments in health systems should move beyond vertical approaches to developing public health capacity and place greater emphasis on strengthening the interactions between public health functions and institutions. Development of linkages and their enablers require a purposeful, proactive focus that establishes and strengthens linkages over time and cannot be developed during an outbreak or other public health emergency.

INTRODUCTION/RATIONALE

COVID-19 has exposed how breakdowns in the execution of public health functions can lead to devastating health impacts. National Public Health Institutes (NPHIs) have an important role in the performance of these functions. NPHIs are ‘science-based

SUMMARY BOX

- ⇒ COVID-19 illustrated how breakdowns in the execution of core public health functions can lead to devastating impact on economic and social well-being in even the most industrialised countries.
- ⇒ Establishing ‘linkages’ between essential public health functions and organisations improves overall public health performance.
- ⇒ National Public Health Institutes (NPHIs) are uniquely positioned to foster these linkages by bringing multiple functions under the responsibility of a single organisation.
- ⇒ Emerging evidence demonstrates the value of NPHIs and the improved linkages they facilitate between essential public health functions and other entities.
- ⇒ We propose a greater focus on integrated health systems and continued development of the evidence base for linkages among essential public health functions.

organisations (or networks of organisations) that provide leadership and coordination for public health at the national level’.¹ NPHIs can represent different administrative structures, from an agency under the authority of a Ministry of Health (MoH) to a parastatal organisation with blended public and private funding. What NPHIs share in common is their practice to bring together, at a national level, several public health functions together under one institutional home or under a strong coordination mechanism.

According to the US Centers for Disease Control and Prevention (US CDC), essential public health functions (EPHFs) are ‘the public health activities that all communities should undertake’.² They typically include workforce development, surveillance, public health research, laboratory services, health

promotion, outbreak response and emergency management. In the absence of an NPHI, these public health functions may be implemented by different institutions or sectors without joint planning or leadership. This can cause inefficiencies, reduced accountability, breakdowns in coordination, slower public health response times, limited autonomy of public health organisations due to political influence and other suboptimal outcomes.³⁻⁶

This paper describes how NPHIs and other health authorities can enhance the coordination of public health functions and actors by improving linkages. Although NPHIs are not the only health authority that is capable of fostering public health linkages and enablers, they are uniquely poised to do so given their national mandate on public health and their existing national coordination of many public health functions. Our analysis was guided by 2 years of formative research by US CDC on linkages in public health, business and organisational development contexts and consultation with global public health experts, as well as leaders of NPHIs from Burkina Faso, Colombia, Georgia, Korea, Nigeria and Norway.

Linkages have been noted as an important feature of health systems by major actors such as the World Health Organization (WHO),⁷ the International Association of NPHIs (IANPHI)⁸ and US CDC. However, research on this topic is scant. Informed by our own research, we present a working definition of public health linkages, the emerging evidence base, a novel typology for linkages and a framework for key enablers of public health linkages. Our aim is to provide the global health community opportunities for strengthening linkages and to encourage more research in this area.

DEFINING PUBLIC HEALTH LINKAGES AND THEIR ENABLERS

We define public health linkages as practical, replicable activities or actions that facilitate collaboration between public health functions or organisations to improve public health impact.

Enablers of public health linkages are institutionalized processes, assets and organisational characteristics that strengthen linkages between public health functions or organisations.

EMERGING EVIDENCE OF THE IMPACT OF LINKAGES FOSTERED BY NPHIS

Our extensive review of the public health and business literature identified numerous outcomes of linkages led by NPHIs. They include improved prevention and control of outbreaks, faster detection of threats, more effective multisectoral and international coordination in response to public health threats, and improved integration of vertical disease programme services.

In the public health literature, NPHIs have been found to concentrate the financial, personnel and material resources of public health organisations into a single institution.⁹⁻¹³ This leads to improved capacity to generate and share data and evidence between essential

users (eg, laboratory and epidemiology staff) to inform public health decisions and policies.^{2 9 11} NPHIs also increase countries' capacity to mount a quick, decisive, and coordinated response during a public health emergency due to their ability to efficiently manage decisions and personnel across functions.^{8 9 11 14 15} NPHIs further support enhanced emergency response, due to their role in information-sharing and collaboration among government and private healthcare facilities, academia and nongovernmental organisations.¹⁶

Using linkages, NPHIs can also standardise public health processes across functional domains, such as health promotion and laboratory diagnostics.^{10 11} These processes enable the consistent application of evidence-based methods across health conditions.^{10 11} NPHIs are also shown to improve coordination in the planning and management of vertical public health programmes, by bringing them together under one entity. This helps overcome the well-documented negative effects of siloed or vertical health programming.¹⁷⁻¹⁹

In the business literature, particularly that related to organisational development, substantial cost savings were documented in multiple industries that employed cross-functional teams instead of employing best practices in individual departments separately.²⁰ Cross-functional linkages also allow businesses to 'rectify mistakes or procedural errors more effectively', manage crises and identify long-term solutions.²¹ A systematic review of public affairs literature found that 'one of the most promising practice-based approaches in public health is the development of interorganisational partnerships as a way to attain resources, share knowledge, and thus improve population health'.²²

NOVEL TYPOLOGY FOR LINKAGES

We propose the following typology to categorise important public health linkages.

- ▶ **Functional:** linkages between two public health functions.
- ▶ **Multifunctional:** linkages between three or more public health functions.
- ▶ **Multisectoral:** linkages between government, private, academic, non-governmental sectors or between sectors within the government.
- ▶ **Multilevel:** linkages between entities at national and subnational levels of the health system.
- ▶ **International:** linkages between national entities and foreign governments, companies, associations, donors or multilateral partners.

Functional linkages between two EPHFs

Functional linkages can exist between any two EPHFs. Surveillance and laboratory services are two highly interdependent functions where NPHIs may facilitate linkages. Laboratory services produce pathogen diagnostic and genotyping information that epidemiologists use to understand disease transmission and to design control

interventions. Likewise, epidemiologists communicate with laboratories regarding their data needs, to improve laboratory data collection and management. NPHIs can facilitate this bidirectional information exchange by developing formal protocols for sharing specimens and genotyping data.

These linkages introduce new opportunities for approaching public health functions. For example, NPHIs often establish a common data platform that laboratorians, epidemiologists and researchers can use to query data. Common data platforms allow laboratory database teams to conduct epidemiological analysis to identify clusters or anomalies as a form of early outbreak detection. Further, a single platform allows a variety of experts to work from a single source of evidence and creates resource efficiencies for the public health system. NPHIs can also produce epidemiological bulletins that bring together laboratory and surveillance data into a shared product, enhancing the dissemination of information. In Colombia, a national laboratory information system (SIVILAB) integrates the monitoring of biological samples collected at subnational laboratories, as well as entomological surveillance processes, water quality surveillance and performance evaluation for improved detection and control of emerging diseases and outbreaks.²³

Multifunctional linkages

NPHIs facilitate multifunctional linkages among three or more functions in the context of a disease control programme, campaign or public health emergency. Public health communication campaigns can bring together surveillance, laboratory and health promotion teams to deliver public health messaging that is appropriate and targeted to disproportionately affected groups. These campaigns may also use public health research to evaluate the impact of messages on individual behaviour (eg, vaccine uptake) and guide future health promotion interventions. In the country of Georgia, the hepatitis C (HCV) elimination programme brought together health promotion, surveillance, laboratory and other functions in concert to achieve a common goal of eliminating HCV (Interview, Georgia National Center for Disease Control and Prevention, 2022). Similarly, during public health emergencies, NPHIs collate surveillance and laboratory data with public health research to inform national policies related to testing, laboratory practice, vaccine eligibility and more. Workforce development, such as the creation of rapid response teams before and during emergency response, often is based on this data and research.

Multilevel linkages

Multilevel linkages are those between central-level public health actors and those at subnational levels (eg, regional, provincial, district, municipal). Many NPHIs do not have staff or infrastructure at subnational levels of the health

system, so their ability to create subnational linkages is critical to their public health mission.

NPHIs may set standards, provide integrated data platforms, and train staff at clinical facilities to support local surveillance data collection that is integrated into a national surveillance system. NPHIs may also establish procedures and guidelines for regional and local laboratories to conduct diagnostics, collect and transport specimens, and conduct quality control as part of an integrated laboratory network.

NPHIs can also lead and coordinate health security initiatives across subnational levels. For example, the Nigeria NPHI's Directorate of Subnational Support was formed, in part, to help build and strengthen a national network of state-based Public Health Emergency Operations Centres (PHEOCs) to improve the early detection and control of public health threats. This network has enabled more rapid and effective responses to Lassa fever, Ebola virus and COVID-19 (Interview, Nigeria Centre for Disease Control, 2022).

Multisectoral linkages

Multisectoral linkages are those between public, private, academic and not-for-profit sectors. NPHIs facilitate these linkages as part of an emergency response or routine public health programme management. In Italy, the NPHI established 22 different topical and multisectoral COVID-19 working groups to manage various aspects of the response.²⁴ In Germany, where 90% of childhood vaccines are delivered through private providers, the NPHI uses its national authority to set requirements for private clinical providers. These requirements allow the NPHI access to data that is combined with insurance claims to produce aggregate vaccine information needed for policy-making.²⁵

Multisectoral linkages can also represent cross-disciplinary collaborations, even between public sector agencies. For example, to address the threat of zoonotic infections to human health, many NPHIs are adopting One Health approaches, where they actively collaborate with policymakers, researchers, laboratorians and other staff across agriculture, forestry, environment, wildlife management and human health agencies.²⁶ Similar multisectoral tactics are being used to address antimicrobial resistance, a complex problem where the WHO reports that 'single, isolated interventions have limited impact'.²⁷

International linkages

International linkages are collaborations between a national entity with foreign governments, multilateral organisations, donors and international associations. NPHIs are often the focal point for international collaboration, serving as the responsible authority to report surveillance data to WHO on notifiable conditions. NPHIs also facilitate collaboration on cross-border health interventions, such as contact tracing or concurrent mass drug administration in border regions. The

Table 1 Country examples of public health linkages

Linkage type	Public health functions/actors	Country	Linkage description
Functional	Laboratory, surveillance	USA	The U.S. CDC PulseNet programme links laboratory and surveillance services for the early detection and control of foodborne, waterborne and zoonotic diseases. A network of over 80 laboratories submits genotyping data from outbreak samples to national databases. US CDC epidemiologists analyse the data for disease clusters, which trigger epidemiological investigations. The programme also intentionally designs national and regional meetings to bring laboratory and surveillance professionals together to collaborate and conduct joint training, where participants learn important concepts from the other discipline. ³⁸
Functional	Outbreak response, health promotion	South Korea, Ukraine, UK	In the COVID-19 response, outbreak response teams worldwide provided health promotion teams with real-time data on communities with elevated risk of disease to enable targeted risk communication. NPHIs in South Korea, Ukraine and other countries targeted messages at religious congregants, while Public Health England provided webinars on how employers could mitigate occupational health exposures for employees. ³⁹
Functional	Outbreak response, workforce development	Norway, Other Europe	The European CDC maintains a 2-year fellowship programme that trains professionals in detection and management of communicable diseases through placement at NPHIs. For example, in Norway fellows present data at the NPHI's daily briefing of over 600 participants. They jointly participate in outbreak assignments, and NPHI staff also review their doctoral dissertations. ³⁸
Functional	Outbreak response, workforce development	Angola	Angola created and trained a rapid response team (RRT) with members from the armed forces and staff from the Ministry of Health (MoH). This multifunctional RRT has experts from epidemiology, laboratory, communications and other cadres. It can deploy locally, nationally or internationally. In 2019, it sent 54 members to support response efforts in Mozambique after cyclone Idai. ⁴⁰
Multifunctional	Outbreak response, health promotion, workforce development	Various	During polio outbreaks, NPHIs (eg, Nigeria) often cultivate cultural understanding among their workforce to promote vaccine adoption and overcome stigma. Training of health and community workers to understand social issues, communicate appropriately and address the public's concerns is a linkage between health promotion, workforce development and outbreak response. ³⁸
Multifunctional	Laboratory, surveillance, workforce development	Vietnam	Vietnam developed a sentinel surveillance system for antimicrobial resistance involving 16 laboratories and 6 hospitals to track and report healthcare-associated bloodstream infections and urinary tract infections. It also developed a cadre of provider 'champions' to improve infection prevention and control practices at health facilities nationwide. ⁴¹
Multifunctional	Outbreak response, laboratory, workforce development, public health research	Haiti	During a cholera outbreak in Haiti, the Ministry of Public Health and Population (MSPP) deployed field response teams to investigate local reports of cholera infections. National laboratories confirmed infections within hours, and the MSPP adjusted future strategies based on research including case-control studies and mortality surveys. ⁴²
Multilevel	NPHI, Local health departments	USA	The US CDC routinely engages and supports local health departments during an outbreak response. For example, under the Zika Emergency Operations Centre, the Pregnancy and Birth Defects Task Force established the Local Health Department Initiative (LHDI). The LHDI seconded public health professionals to 28 health departments, engaging 2464 clinical providers and testing 24 971 women for the disease across US states and territories as of January 2018. ⁴³

Continued

Table 1 Continued

Linkage type	Public health functions/actors	Country	Linkage description
Multilevel	NPHI, state health authorities, local health authorities	USA	During the COVID-19 pandemic, US 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. ⁴⁴
Multisectoral	NPHI, MoH, academia, other line ministries, healthcare, laboratories	Italy	During COVID-19, Italy's NPHI established 22 multisectoral working groups that governed the nation's response. These working groups included organisations such as the 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. ²⁴
Multisectoral	NPHI, private sector laboratories, other line ministries	Ukraine	In Ukraine's COVID-19 response, the NPHI established a system whereby autonomous laboratories can enter testing results into the national case registry. Results are published to the Ministry of Digital Transformation's Act at Home self-isolation app, which enables patients isolating at home to immediately access their results and make informed quarantine decisions. ⁴⁵
International	Multilateral, regional multilateral, international NGOs, 16 country governments	16 West and Central African countries	The World Bank Regional Disease Surveillance Systems Enhancement (REDISSE) Programme 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 and vaccines were established in Côte d'Ivoire. ²⁸
International	NPHI, regional country governments	Germany, other Europe	In Germany, cross-border contact tracing is conducted by the NPHI. Authorised by the German Infection Prevention Act, the NPHI is responsible for bidirectional communication of cases and contacts with other European countries through the Early Warning and Response System for European Union countries. ⁴⁶

CDC, Centers for Disease Control and Prevention; NGO, non-governmental organisation; NPHI, National Public Health Institute.

World Bank Regional Disease Surveillance Systems Enhancement Programme is an 'interdependent series of projects' across 16 West and Central African nations. It encourages information sharing, policy alignment, joint planning and asset sharing.²⁸ NPHIs also collaborate with other NPHIs to strengthen national and regional public health capacities. These international networks have been shown to 'have strong potential for ... strengthened global public health.'³

Table 1 provides a series of linkages deployed by NPHIs. Linkages of each type are presented.

Key enablers of strong linkages

Organisational enablers are strategic for transforming business processes or functions.^{29–32} Based on our research and consultation, we identify the following as key enablers for public health linkages.

- Policies, agreements and legislation: formalised processes, laws and policies which guide and, in some cases, mandate intraorganisational and interorganisational collaboration.

- Infrastructure: physical structures, shared assets, information systems, and platforms and frameworks to support collaboration.
- Governance, funding and resources: leadership commitment, financing and shared planning to facilitate collaboration.
- People and organisational culture: trust, relationships, history of joint work and skills to support cross-functional linkages.

Policies, agreements and legislation

Decrees, statutes, policies, memoranda of understanding and standard operating procedures (SOPs) can guide or mandate collaboration between functions and organisations. Policies governing NPHI relationships with subnational organisations enable efficient collaboration during outbreak response or routine activities such as disease surveillance. Legal frameworks provide an NPHI with a clear mission, governance structures, leadership and funding opportunities. SOPs can improve cross-functional collaboration by offering predictability in procedures and making decision-making more routine

in nature.³³ Further, clearly defined processes for engagement have been shown to improve crisis management by facilitating information exchange and coordination between teams.³²

Infrastructure

Physical structures for collaboration enable staff from different teams to work together.³⁴ NPHIs may establish incident command centres or PHEOCs, regional offices or colocation of staff within a single campus or building. Similarly, organisational structures, such as public health observatories, interagency taskforces or topical networks, can facilitate linkages. Effective structures should create fluid boundaries that reduce barriers to collaboration and encourage equity in network communication and decision-making.²² Information systems can support many linkage types by optimising opportunities for data-sharing between stakeholders, such as through interoperability of information systems using cloud-based platforms and common data standards.

Governance, funding and resources

Leadership can establish a clear vision and motivate staff to work together across siloes, even without a traditional supervisory chain of command. National plans, such as staffing plans, preparedness plans and cross-sectoral disease control plans, further establish common objectives, activities and outcomes that help unify disparate teams and organisations. Techniques such as systems mapping and role mapping, which identify and facilitate understanding of health system actors and roles, are also enablers.¹⁴ Funding enables linkages when it is dedicated to supporting collaboration between teams or entities or when funding resources are shared between groups.²²

People and organisational culture

A key enabler in this category is for the NPHI to be a trusted and credible source of information.³⁵ Additionally, effective cross-functional collaboration depends on the degree of trust between staff of the NPHI and between the NPHI and other organisational actors. Related, a history of joint work and positive relationships between organisations can support linkages before they are needed and can be a resource in outbreak response. Cultivating systems thinking and an organisational culture that rewards a cross-functional mindset are also enablers, by encouraging NPHI leaders and personnel to view systems and relationships holistically rather than as individual components.³⁶

Table 2 highlights how enablers have supported impactful linkages in the countries of Georgia, Nigeria and South Korea.

CONCLUSIONS

Fostering linkages and enablers among public health functions and organisations is a promising strategy to improve public health impact. NPHIs are uniquely positioned to both establish these linkages and support the

enabling conditions that strengthen their impact. There is no one-size-fits-all approach to how NPHIs establish linkages; delivery of public health functions is specific to a country and its health systems.

Developing and retaining linkages within large government institutions is complex. Literature has noted multiple challenges faced by NPHIs when collaborating with other health actors.³⁷ Lacking physical colocation with key partners such as their MoH may impede regular collaboration. If the roles of the NPHI are not clear, there may be tension with subnational government entities or other partners. Newer NPHIs, in particular, have noted difficulty in securing recognition from the MoH or partner organisations. There can be confusion when roles remain shared. For example, emergency response has been noted as having roles from both the NPHI and the MoH, which can cause functional duplication or other problems if emergency response subfunctions do not have a lead agency designated in law or in shared policy.

Overcoming these challenges requires a purposeful investment of attention and resources to strengthen linkages and their enablers, including those outlined in this paper. Indeed, these linkages are specifically designed to cultivate greater collaboration (linkages) between EPHFs and between key health and non-health actors, which may help to avoid the challenges of role confusion, duplication, fragmentation and more. For example, clear legislation that articulates the roles and authorities of the NPHI will reduce confusion and tension in collaboration with other actors. Physical infrastructure such as shared meeting space and data-sharing platforms can facilitate linkages with the MoH or other important line ministries, which can improve synergistic collaboration towards a common population health outcome.

NPHIs can begin by assessing their linkages and enablers—using the frameworks provided in this paper—and identifying where improvements could be made to enhance efficiency and impact. This is particularly valuable amidst resource constraints, as it maximises the impact of existing investments and activities with incremental, collaboration-oriented tactics. Solutions to develop public health linkages then should be incorporated into routine NPHI strategic and operational planning cycles so they are given appropriate visibility and oversight. Similarly, investments in health systems should move beyond vertical or siloed capacity-building approaches and give greater focus to strengthening the interactions between public health functions and between institutions to accelerate health systems impact.

Importantly, linkages and their enablers cannot be developed overnight, in the context of an outbreak, or during a public health emergency. Relationships, trust, effective leadership, a history of joint action, SOPs and other enablers require proactive focus that establishes capacity progressively over time. To this end, strong buy-in and commitment to linkages are needed at the highest levels of institutional and governmental leadership.

Table 2 Enablers as factors in creating and strengthening linkages in Georgia, Nigeria and South Korea

Public health linkage examples	Enablers
<p>Georgia deployed multifunctional linkages in the fight against hepatitis C (HCV). In 2015, Georgia faced one of the highest burdens of HCV. The Government of Georgia, with support from US CDC and a pharmaceutical partner, set an ambitious aim—to reduce HCV by 90%. To start, surveillance, laboratory and clinical data were combined in one database with unique patient identifiers for population-level tracking of cases from suspected to confirmed infections, and to assist providers to connect patients to treatment. Georgia further deployed a 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 were reimbursed through the MoH National Health Agency with quality control and proficiency testing conducted by the NPHI. Public health research was coordinated by a Scientific Committee co-chaired by the NPHI and US CDC which has approved over 80 research proposals to inform programme delivery. Finally, workforce development offered continuing education and clinical guidelines for management of HCV infection.⁴⁷</p>	<ul style="list-style-type: none"> ▶ Strong political commitment through a formal decree signed by the prime minister. ▶ A strategic plan inclusive of multisectoral stakeholders. ▶ Integration of the private sector, coordinated by the Technical Advisory Group and Clinical and Scientific Committees. ▶ Data generated by the NPHI shared openly with relevant service providers, to help identify patients lost to follow-up. ▶ Strong relationships with community organisations and trust with key populations.
<p>Nigeria's NPHI has adopted a strong set of multilevel linkages to capacitate and coordinate subnational actors in the pursuit of emergency response and management. NCDC created a unit to support public health activities at state and local government levels (directorates of subnational support). It also established a network of state-based public health emergency operations centres (PHEOCs). The NPHI provides training, equipment and guidance to state PHEOCs and supports coordination under the national PHEOC. It deploys epidemiologists to states, provides continuous training of state staff, and includes states in simulation exercises. Many state health authorities graduated from the NPHI's Field Epidemiology and Laboratory, Training Programme.</p> <p>The NPHI further leads disease-specific working groups that bring together national and subnational actors to advance coordination and knowledge-sharing. The Surveillance Outbreak Response Management and Analysis System (SORMAS)—an integrated biosurveillance platform—generates data in real-time from subnational authorities to detect and control outbreaks.⁴⁸</p>	<ul style="list-style-type: none"> ▶ 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 were binding on states. ▶ Continuous training of state health staff to address turnover and emerging skills needs. ▶ Close-working relationships between NPHI and state health staff. ▶ Continuous advocacy with governors and other state stakeholders to sustain support. ▶ Real-time data-sharing practices using a disease outbreak surveillance system via SORMAS, with controls for access and ethics review. ▶ WHO Joint External Evaluation as a shared vision for capacity gaps and priority actions.
<p>South Korea's NPHI played a pivotal national leadership role in the COVID-19 response. Among its interventions, it supported important multisectoral linkages with private laboratories to make early testing widely available. The NPHI used its convening power to bring in vitro diagnostic manufacturers together shortly after the first COVID-19 case was diagnosed, to encourage them to produce COVID-19 tests for national use. The NPHI also brought private medical laboratories, hospital laboratories and public sector laboratories into an integrated network and provided training, supplies, quality assurance and guidance. A multiagency government coordinating group provided biosafety facilities and research and development support to private sector trials for COVID-19 treatment and vaccines while a research consultation body of public and private research institutes collaborated to provide guidance on research and development of COVID-19 treatment and vaccines.⁴⁹</p>	<ul style="list-style-type: none"> ▶ Strong political commitment and public trust in the NPHI's commissioner. ▶ Korea's Emergency Use Authorisation, established after Middle East Respiratory Syndrome (MERS), enabled private labs to rapidly deploy diagnostic tests for COVID-19. ▶ Pre-COVID-19 investment in commercial infectious disease diagnostic technology created infrastructure for rapid development of COVID-19 diagnostics. ▶ Korean government guaranteed reimbursements of a minimum quantity of tests for approved manufacturers. ▶ NPHI-led clinical evaluation of new diagnostic tests, and data submissions from private manufacturers' requests for approval. ▶ Transparency and trust by sharing plans and information with private stakeholders, through routine meetings and communication.
<p>CDC, Centers for Disease Control and Prevention; MoH, Ministry of Health; NCDC, National Center for Disease Control; NPHI, National Public Health Institute.</p>	

We recommend further research and consultation that refines our collective understanding of linkages and their impact on public health. This includes documenting more examples and leading practices of different linkage types in different health systems contexts and evaluating the relationship between linkages and public health outcomes.

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