Exploratory Literature Review of the Role of National Public Health Institutes in COVID-19 Response

Alexandra Zuber,[1] Yesser Sebeh,[1] Dennis Jarvis,[2] Shelly Bratton[2]

To help explain the diversity of COVID-19 outcomes by country, research teams worldwide are studying national government response efforts. However, these attempts have not focused on a critical national authority that exists in half of the countries in the world: national public health institutes (NPHIs). NPHIs serve as an institutional home for public health systems and expertise and play a leading role in epidemic responses. To characterize the role of NPHIs in the COVID-19 response, we conducted a descriptive literature review that explored the research documented during March 2020–May 2021. We conducted a name-based search of 61 NPHIs in the literature, representing over half of the world's NPHIs. We identified 33 peer-reviewed and 300 gray articles for inclusion. We describe the most common NPHI-led COVID-19 activities that are documented and identify gaps in the literature. Our findings underscore the value of NPHIs for epidemic control and establish a foundation for primary research.

National public health institutes (NPHIs) are "science-based organizations… that provide leadership and coordination for public health at the national level" (*1*). NPHIs provide an institutional home for many public health functions, which can improve coordination of public health activities; streamline human and financial resources; and improve the generation, sharing, and use of public health data and evidence (*2*–*9*). During public health emergencies, NPHIs can increase countries' capacity to mount quick, decisive, and coordinated responses (*2*,*3*,*5*,*10*,*11*). An NPHI is often a government agency within a ministry of health but may in some cases represent a parastatal or nongovernmental entity. Approximately half of the countries in the world have an NPHI (n = 94), and they vary in maturity, form, and function (*12*).

Author affiliations: Ata Health Strategies LLC, Washington, DC, USA (A. Zuber, Y. Sebeh.); US Centers for Disease Control and Prevention, Atlanta, Georgia, USA (D. Jarvis, S. Bratton)

DOI: https://doi.org/10.3201/eid2813.220760

Despite their critical role, however, NPHIs have not been a focus of the growing body of research related to characterizing the response to COVID-19 by national governments (*13*–*16*; C.T. Lee et al., unpub. data, https://www.medrxiv.org/content/10.1101/2021.02.02.21251013v1). In 2021, researchers from the World Health Organization and the International Association of National Public Health Institutes (IANPHI) reported that COVID-19 revealed global inequities in public health capacities and established that an "urgent need to examine sources of global knowledge and understand how NPHIs… can be better used, particularly in under-resourced settings" (*17*). To this end, we conducted an exploratory, descriptive literature review to examine 1 question: What clues can the literature give us on the role of NPHIs in the COVID-19 response globally?

Methods

We conducted an electronic database search of articles published in scientific journals (peer-reviewed literature) and a targeted search of documents or reports published outside of academic publishing (gray literature) (Appendix 1, https://wwwnc.cdc.gov/EID/article/28/13/22-0760-App1.pdf). For our electronic search, we selected the World Health Organization COVID-19 Global Research Database on the basis of its comprehensive inclusion of articles from multiple electronic databases and its topical focus on COVID-19 (Figure 1) (*19*). Our search terms (Appendix 2 Table 1, https://wwwnc.cdc.gov/EID/article/28/13/22-0760-App2.pdf) included "national public health institute" as well as the proper names of 61 NPHIs, as listed on the IANPHI website (*12*). We designed a sample frame of these

[1]These co–principal investigators contributed equally to this article.

[2]These senior authors contributed equally to this article.

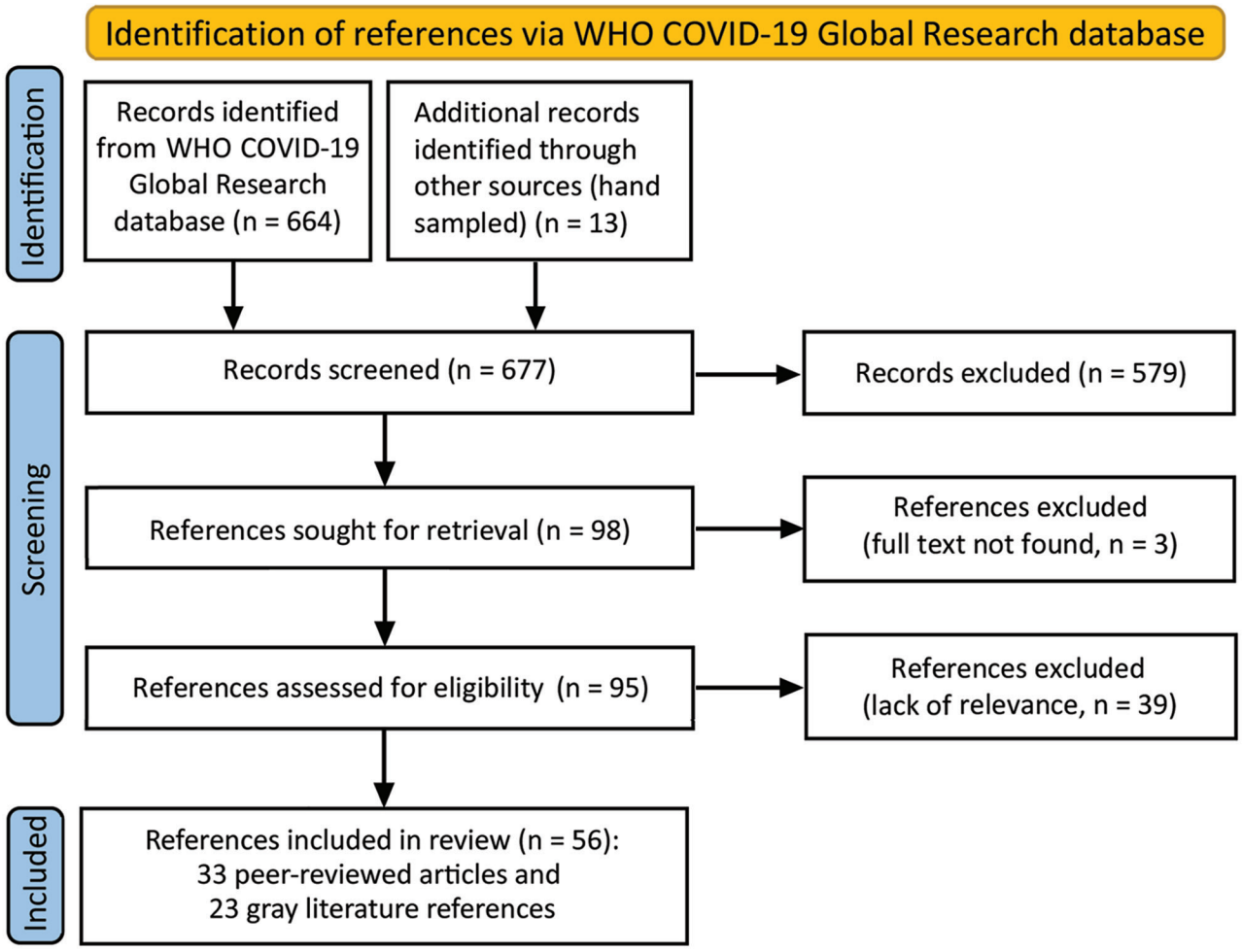

Figure 1. Electronic database search conducted for literature review of the role of national public health institutes in COVID-19 response. Source: (*18*). WHO, World Health Organization.

61 NPHIs by categorizing all 111 IANPHI members by their country's position on 4 World Bank income levels (i.e., high, upper-middle, lower-middle, and low) and 6 World Bank regions. We then selected 2–3 NPHIs per tier from each of the 6 regions. The NPHIs represented 52 countries because some countries have >1 IANPHI. One researcher conducted the electronic search.

We also searched gray literature for a subsample of 8 NPHIs (selected from the 61 NPHI sample frame). We selected 2 NPHIs from each World Bank income tier, at least 1 per World Bank region. Two researchers searched Google, websites, and social media accounts of the 8 NPHIs. Our Google search terms included the proper name of each of the 8 NPHIs in English, the name in the language of origin, and "COVID-19." For both searches, we included all studies, reports, new articles, and websites in any language that described activities conducted by NPHIs as part of the COVID-19 response. We used Google Translate for articles not in English (Appendix 2 Table 2).

We imported electronic search articles to NVIVO software (*20*) and gray search articles to an Excel database (Microsoft, https://www.microsoft.com) for qualitative thematic analysis (Appendix 2). We conducted our analysis by following a 3-step, evidence-based strategy (*21*). We used a codebook of deductive and inductive codes and established a coding agreement between reviewer pairs through independent coding and comparison of 2 sample returns. Our conceptual framework was the IANPHI Essential Public Health Functions framework (*22*). This framework describes 11 core public health functions supported by NPHIs, which we used as our exclusive list of deductive codes to categorize NPHI activities in the COVID-19 response (Appendix 2 Table 3).

Results

Characteristics of the Literature

From our electronic database search, we screened 667 references by title and abstract and reviewed the full text of 95 articles. A total of 33 peer-reviewed and 23 gray articles met our inclusion criteria. Through our search of gray literature, we identified 277 relevant returns: 75 websites, 62 news articles, 60 social media postings, and 80 guidelines and reports (Appendix 2 Table 4). All articles were published during March 2020–May 2021; 84% were published during June 2020–January 2021.

Articles included in the review described NPHI activities in 20 countries, which represent 39% of the 52 countries searched and 21% of countries globally that have NPHIs (Figure 2; Appendix 2 Table 5). Most articles summarized NPHI activities in a single country (only 3 articles featured NPHI activity in >1 country). The literature from the electronic search was skewed toward 3 countries: Brazil, South Korea, and the United States (representing 33 [59%] of 56 electronic search returns). Returns from the gray literature search of 8 countries represented 236 (71%) of total returns from all searches. As a result, 269 (81%) of the total articles included in the review were focused on 10 countries. The electronic search returned no articles or reports for 34 (65%) of the countries searched.

NPHI Functions and Activities during the COVID-19 Response

COVID-19 activities among the 20 NPHIs included in this review were reported across all 11 public health functions but most commonly for 5 functions (Appendix Table 3). Because included articles did not document NPHI activities in a consistent fashion across all functions in each country, this summary is an underrepresentation of the full role of each NPHI.

Public Health Surveillance, Problem Investigation, and Control of Risks and Threats to Public Health

Collecting and Sharing Surveillance Data

NPHIs were lead authorities for collecting and analyzing epidemiologic data to project COVID-19 cases,

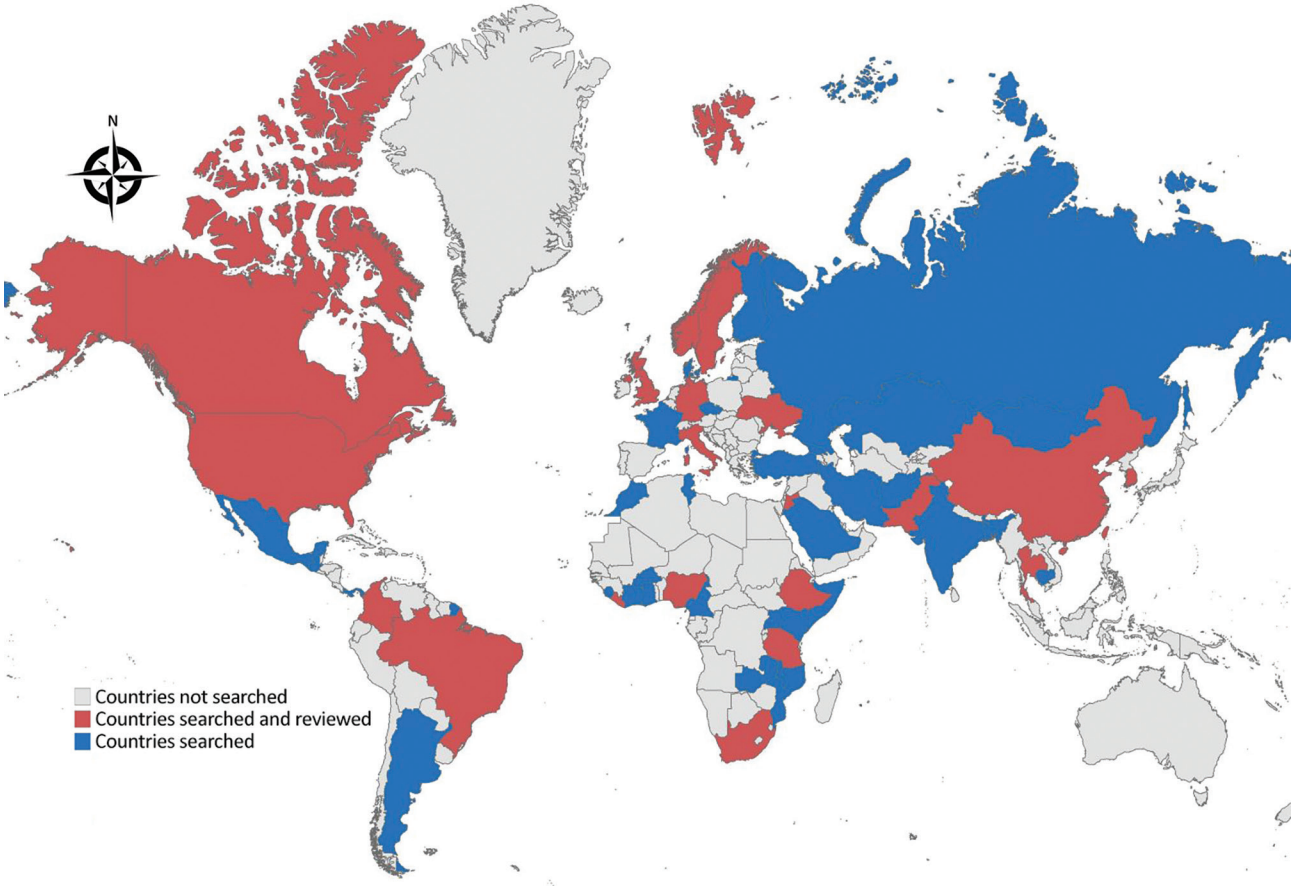

Figure 2. Countries with International Association of National Public Health Institutes members searched and reviewed for literature review of the role of national public health institutes in COVID-19 response.

deaths, transmission patterns, and hospitalization rates. To manage COVID-19 data, NPHIs from England and Italy built upon existing integrated disease surveillance systems for infectious disease, including use of sentinel surveillance, vaccine uptake, and household and seroprevalence studies. NPHIs from Canada, Colombia, and Brazil designed and deployed mathematical models to determine scenarios for COVID-19 transmission and to evaluate public health approaches such as quarantine and social distancing. For example, to provide real-time projections of COVID-19 transmission, hospitalizations, and deaths, Brazil used smartphone Global Positioning System data and measured population mobility in combination with COVID-19 deaths, hospital use, and adherence to isolation measures.

Setting COVID-19 Case Definitions

For the purposes of disease surveillance, NPHIs set case definitions or standard criteria to classify whether a person has COVID-19. NPHIs in Pakistan, Ethiopia, South Korea, and Jordan established case definitions for screening of passengers at international airports, laboratory and hospital managers of COVID-19 case-patients, and healthcare workers.

Managing Laboratory Services

Many NPHIs led laboratory services in the COVID-19 response. For example, the South Korea NPHI partnered with the Korean Society for Laboratory Medicine to develop comprehensive guidelines for laboratory diagnostics for COVID-19, which included selection of persons to test, transport of specimens, diagnostic methods, interpretation of test results, and biosafety. The Pakistan NPHI disseminated standard operating procedures for specimen collection, management, and transport of samples for COVID-19 testing.

Many NPHIs produced the first diagnostic technology for COVID-19 in their countries, including collecting the first samples of COVID-19 and genotyping the virus. The Ethiopia NPHI repurposed existing personnel and infrastructure for malaria, HIV, and other disease research to provide diagnostic capability for COVID-19. The South Korea NPHI leveraged previous efforts to improve coronavirus testing in the wake of the Middle East respiratory syndrome (MERS) epidemic to rapidly establish COVID-19 testing capability as early as December 2019, which enabled extensive early detection of cases. NPHIs from South Korea and Thailand were also involved in genomic sequencing of SARS-CoV-2 virus, which became especially valuable for public health decision-making as new strains emerged.

As COVID-19 cases increased, several NPHIs were at the forefront of COVID-19 case confirmation. The Pakistan NPHI built upon its national public health laboratory and laboratory-based systematic influenza surveillance network to make COVID-19 confirmation testing available by using real-time PCR. Italy NPHI laboratories were opened around the clock to perform confirmation testing; they also provided technical support to other central laboratories for confirmation testing. The Brazil NPHI created COVID-19 Diagnostic Support Units with a testing capacity of 20,000 tests/day.

NPHIs also typically designed and managed the public health laboratory network within each country. The South Korea NPHI ensured that real-time diagnostic capability was established in 18 provincial public health laboratories, and test results became available within 6 hours. The Colombia NPHI first collected all patient samples from 32 departments nationwide for testing in its national reference laboratory; thereafter, it decentralized the process so that ≈172 reference laboratories nationally could support COVID-19 testing. The South Korea NPHI performed quality control of all public and private sector laboratories for in-country COVID-19 diagnostic testing.

Screening

NPHIs were engaged in COVID-19 screening of travelers from high-risk countries and of patients, guests, and employees of the hospital system. For example, the US NPHI partnered with the airline industry and other federal authorities to set standards for medical evaluation of passengers before allowing them entry into the country and for mandatory quarantine. Those data were shared with state-level health authorities for follow-up.

Testing

NPHIs were lead authorities for COVID-19 testing, which included developing national multisectoral testing plans, overseeing testing facilities, and providing training and technical support to testing facilities across sectors. To improve data matching for results, the England NPHI established procedures for individual self-testing, which included arranging for samples to be sent to the Public Health England national laboratory and linking to the person's National Health Service identification number. The Liberia NPHI provided COVID-19 testing directly to all incoming air passengers. The Pakistan NPHI monitored subnational testing activities and developed

quality indicators for point-of-care testing. To expand COVID-19 testing, it also provided training, technical advice, and support to testing facilities nationwide.

The South Korea NPHI developed a national plan for COVID-19 testing, which included 137 testing facilities across public facilities, public hospitals, and referral laboratories. It also managed an advanced testing network, which included 638 public health centers, a COVID-19 hotline for healthcare providers, and drive-through and walk-through testing centers to enable throughput of patients in ≈10 minutes. Testing strategies in South Korea were also tailored to the level of risk identified by the NPHI, and highly affected regions were targeted for testing by deploying rapid response teams.

Quarantine

NPHI support for quarantine activities included helping formulate quarantine policy, providing healthcare service to quarantined populations, and working with government agencies to enforce quarantine. The Liberia NPHI collaborated with county governments and international partners to set up a quarantine facility. The Jordan NPHI provided special medical and healthcare services to quarantined populations. The China and South Korea NPHIs provided data on confirmed cases for local-level police and other authorities to support home-based and facility-based quarantine implementation.

Contact Tracing

NPHIs commonly led contact tracing programs. Through the use of technology and wide-ranging multisectoral partnerships, the South Korea NPHI managed a single coordinated contact tracing system that combined smartphone data, credit card transactions, closed-captioned television footage, and more, which enabled public health practitioners to determine a patient's movement and potential exposures for the past 48 hours. The database also assisted early research on clusters by providing accurate contact mapping. Through international collaboration, the Germany NPHI conducted cross-border contact tracing with other member states in the European Early Warning System and through communication with International Health Regulation national focal points. The China NPHI conducted contact tracing for all confirmed cases in the country identified from its national disease surveillance system.

Emergency Operations Centers

Nigeria, the United States, and Ethiopia also led Emergency Operations Centers. In Nigeria, the first confirmed COVID-19 case led to activation of the country's National Emergency Operations Centre to level 3, and the Nigeria NPHI led this group with the support of Lagos State Health authorities to conduct strict epidemic control measures.

Public Health Research

NPHIs actively led public health research for COVID-19. NPHIs from Brazil, Colombia, the United Kingdom, South Korea, Norway, Pakistan, Italy, and Canada established networks and platforms for research collaboration. The Norway NPHI established a rapid research review process, which identified evidence needs and conducted evidence reviews in 1–3 days to inform guideline development. All work of this NPHI is published on the Live Map of COVID-19 Evidence, which contained 18,000 publications as of February 2020 (*23*).

NPHIs also conducted research, clinical trials, and published papers related to COVID-19. We found 105 studies with NPHI support, defined as funding (n = 25), data (n = 35), or direct study implementation (n = 13). For example, NPHIs in Colombia, Jordan, and Tanzania conducted seroprevalence studies. NPHIs in Brazil and South Korea conducted clinical trials on treatment, immunization, and mental health effects on healthcare workers as well as epidemiologic studies. NPHIs also made datasets available for other researchers, nationally and internationally.

Prevention Programs and Health Promotion

NPHIs were further involved in COVID-19 prevention efforts through support for vaccination reporting and risk communication. For example, the US NPHI helped manage 2 vaccine reporting systems to obtain efficacy and safety data on COVID-19 vaccines: the Vaccine Adverse Events Reporting System, which aggregates self-reported adverse vaccine events from patients and clinicians, and the Vaccine Safety Data-Link, which gathers hospital data from ≈10 million patients. Both systems enable monitoring of vaccine safety and further studies on rare and severe adverse events. The Colombia NPHI created standard operating procedures for healthcare workers to identify and report vaccine adverse events and register cases with surveillance systems.

NPHIs were involved in risk communication through websites, social media, routine briefings to the public, situational reports, and engagement with communities and multisectoral partners. Health promotion messages and risk communication targeted disproportionately affected populations, such as traditional fishing communities (Brazil), religious

congregants (South Korea and Canada), and employees in occupational settings (England). NPHIs' COVID-19 risk communication activities more commonly focused on a general audience (Italy); restaurants, schools, and nursing homes (Sweden); and other government agencies and clinic settings (United States). In Nigeria, the most popular source of COVID-19 information cited during the pandemic was the NPHI.

NPHIs also worked closely with other sectors and communities to advance their public health messages. The Jordan NPHI started a multisectoral risk-communication campaign on mental health and COVID-19, through partnerships with nongovernmental organizations, academia, public and private media outlets, social media, and religious leaders. The Tanzania NPHI worked with municipalities and local communities to develop a risk communication plan that included relevant media outlets to disseminate culturally appropriate COVID-19 preventive measures. The South Korea NPHI repurposed a 24-hour hotline created for risk communication during the MERS outbreak to support COVID-19 health communication.

Quality Assurance in Personal and Population-based Healthcare Services

Some NPHIs also supported population access to COVID-19 healthcare services, managed surge capacity, and ensured quality of service delivery. The Brazil NPHI, in partnership with the Ministry of Health, built a rapid assembly hospital on its campus, with 200 beds to treat critically ill COVID-19 patients. The South Korea NPHI established a tiered patient-severity index and supported the repurposing of nonhospital facilities for case-patients with mild illness. Private dormitories and training centers were converted into isolation centers for those with severe illness.

NPHIs also provided national guidance and support for infection prevention and control (IPC) procedures in healthcare and public settings. The Italy NPHI participated in a multisectoral working group that provides guidance on IPC measures against COVID-19 transmission in healthcare facilities and maintained a unit dedicated to the management of IPC initiatives. The South Korea NPHI sterilized and fumigated public places such as public transit settings and theaters.

NPHIs also supported risk assessment in healthcare settings by establishing tools for clinicians and occupational health practitioners. For example, the South Korea NPHI developed standard, mandatory symptom screening of all hospital visitors and staff via a smartphone application. It further reduced hospital-based infections by managing supply and demand of face masks through social networks and smartphone applications.

Human Resources Development and Training

As part of the COVID-19 response, NPHIs routinely engaged in human resources development, which included training and deploying staff and forming platforms and working groups to coordinate workforce development activities. Ethiopia, Colombia, Liberia, Pakistan, and South Korea NPHIs conducted workshops and training for laboratorians based in universities and hospitals nationwide. NPHIs commonly partnered with other sectors to advance this training. For example, the South Korea NPHI trained private hospitals and laboratories to use the diagnosis kits in partnership with the Korean Society for Laboratory Medicine Practice; the Pakistan NPHI, together with multiple academic partners, provided online training for laboratory technicians.

NPHIs from Canada, Colombia, Italy, Liberia, and Ukraine also built human resource capacity in case identification and management, contact tracing, surveillance, and IPC. The Liberia NPHI leveraged its experience from the Ebola virus disease response to recruit, train, and deploy contact tracers early in the response. The Jordan NPHI and other partners trained ≈400 healthcare workers nationwide on COVID-19 vaccination.

The US NPHI deployed staff to subnational units to assist in the COVID-19 response. It created a dedicated COVID-19 response section to support state, tribal, local, and territorial health departments. The system deployed hundreds of teams to support subnational teams with data collection, epidemiologic investigations, contact tracing, and more.

Two NPHIs managed training platforms and working groups. The Ethiopia NPHI and partners launched the COVID-19 Ethiopia Health Worker Training Platform, a smartphone-based digital learning platform for healthcare workers responsible for COVID-19 diagnosis and treatment. The Italy NPHI supported a multisectoral COVID-19 training working group that designs standardized training methods, conducts needs assessments, evaluates training, and organizes scientific meetings to share knowledge and best practices.

Discussion

Our literature review revealed that NPHIs played an active role in the COVID-19 response. This role was normative (e.g., setting quarantine policy) and involved implementation (e.g., providing COVID-19

testing). NPHIs rarely acted alone but instead commonly partnered with government authorities at national and subnational levels (including health, education, security, and emergency services); private industry (including private manufacturers, laboratories, and airlines); and civil society (including training institutions, professional associations, and community groups). They also sponsored novel digital health technologies to support contract tracing, quarantine, and population health data analytics.

The engagement of NPHIs in surveillance, public health research, and public health prevention and promotion is consistent with the literature with regard to what are considered core NPHI capabilities (*22*,*24*). However, the active role reported for NPHIs in quality assurance reflects a special role played by NPHIs during an epidemic, in which triaging hospital access and containing hospital-based infections is paramount. Of note, NPHIs routinely leveraged personnel, infrastructure, practices, and policies established in response to previous epidemics (e.g., MERS, HIV, and Ebola) to respond to COVID-19, which illustrates the value of sustained development of epidemic response capability by NPHIs over time.

Limitations of our review included the lack of documentation for 61% of the countries searched and the skew of available articles toward 10 countries, which prevented generalizability of the study findings. It is noteworthy that the highest number of relevant articles was identified by searching NPHI websites and social media, followed by conducting electronic searches by using proper name of the NPHI. Many articles that we screened described the government response to COVID-19 but omitted the role of NPHIs. Few articles offered any comparisons between NPHI activities.

We conclude that there is a gap in the systematic comparison of these institutions with respect to COVID-19, which could elucidate trends, challenges, and best practices in the manner called for by Jakab et al. (*25*). A study by Binder et al., published after our review, contributes to this end (*26*). Those authors conducted a literature review and listening sessions comprising leaders from 10 Africa NPHIs and documented common challenges faced by these NPHIs and innovations. However, they report that their methods did not systematically document NPHI activities with regard to COVID-19, and the article does not document the role of NPHIs outside of Africa (*26*).

To obtain consistent and comprehensive data on the role of NPHIs with regard to COVID-19 globally, we recommend direct data collection through surveys and interviews. Those activities would fill gaps in data by public health function and geography and allow for cross-country comparisons and measuring the degree or intensity of NPHI activities. Survey findings also open up the potential for quantitative analysis of the relationship between NPHI activities and COVID-19 outcomes, such as confirmed cases, mortality rates, and social distancing. Such analyses would benefit from additional information that would enable stratification based on characteristics of NPHIs, such as size, maturity, and funding. Together, this information could build on other analyses that attempt to explain country COVID-19 outcomes (*15*,*16*; C.T. Lee et al. unpub. data, https://www.medrxiv.org/content/10.1101/2021.02.02.21251013v1) and could identify key areas for shoring up public health capacity to improve the response to future epidemics.

Acknowledgments

We acknowledge Jonathan Pearson for his manuscript review and for his gray search of select countries. We also acknowledge Lesley Guyot for her project management support.

This publication was supported by grant or cooperative agreement no. 1 NU2HGH000044-01-00, funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention, the Department of Health and Human Services, The Task Force for Global Health, Inc., or TEPHINET (Training Programs in Epidemiology and Public Health Network).

About the Author

Dr. Zuber is a public health professional who leads a consulting practice that conducts research, evaluation, and program management for global health workforce and health systems programs. Her research interests include strengthening national public health institutes and the public health workforce.

References

1. International Association of National Public Health Institutes. Mission, vision and values [cited 2021 Jun 2]. https://ianphi.org/about/mission.html
2. Njidda AM, Oyebanji O, Obasanya J, Ojo O, Adedeji A, Mba N, et al. The Nigeria Centre for Disease Control. BMJ Glob Health. 2018;3:e000712. https://doi.org/10.1136/bmjgh-2018-000712
3. Barzilay EJ, Vandi H, Binder S, Udo I, Ospina ML, Ihekweazu C, et al. Use of the staged development tool for assessing, planning, and measuring progress in the development of national public health institutes. Health Secur. 2018;16(S1):S18–24. https://doi.org/10.1089/hs.2018.0044

4. Petersen LR, Ammon A, Hamouda O, Breuer T, Kiessling S, Bellach B, et al. Developing national epidemiologic capacity to meet the challenges of emerging infections in Germany. Emerg Infect Dis. 2000;6:576–84. https://doi.org/10.3201/eid0606.000605
5. Koplan JP, Butler-Jones D, Tsang T, Yu W. Public health lessons from severe acute respiratory syndrome a decade later. Emerg Infect Dis. 2013;19:861–3. https://doi.org/10.3201/eid1906.121426
6. McGuinness C, Seccombe DW, Frohlich JJ, Ehnholm C, Sundvall J, Steiner G. Laboratory standardization of a large international clinical trial: the DAIS experience. DAIS Project Group. Diabetes Atherosclerosis Intervention Study. Clin Biochem. 2000;33:15–24. https://doi.org/10.1016/S0009-9120(99)00081-8
7. Omanić A, Kurspahić-Mujcić A, Omanić J. Evolution of Quit & Win program carried through 2002 year in FB&H. Bosn J Basic Med Sci. 2005;5:77–80. https://doi.org/10.17305/bjbms.2005.3340
8. Binder S, Adigun L, Dusenbury C, Greenspan A, Tanhuanpää P. National Public Health Institutes: contributing to the public good. J Public Health Policy. 2008;29:3–21. https://doi.org/10.1057/palgrave.jphp.3200167
9. Jousilahti P. Improving the world's health—the role of National Public Health Institutes. Cent Eur J Public Health. 2006;14:3–5. https://doi.org/10.21101/cejph.b0052
10. Koplan JP, Dusenbury C, Jousilahti P, Puska P. The role of national public health institutes in health infrastructure development. BMJ. 2007;335:834–5. https://doi.org/10.1136/bmj.39356.406377.BE
11. Centers for Disease Control and Prevention. NPHI investments helped Colombia prepare for Zika [cited 2021 Jun 2]. https://www.cdc.gov/globalhealth/healthprotection/fieldupdates/fall-2016/colombia-nphi-zika.html
12. International Association of National Public Health Institutes. Members [cited 2021 Jun 2]. https://ianphi.org/about/member-countries.html
13. Foreign Policy Analytics. From FP Analytics: a country-by-country assessment of government responses to the pandemic [cited 2021 Jun 2]. https://globalresponseindex.foreignpolicy.com
14. World Health Organization. Tracking public health and social measures [cited 2021 Jun 2]. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/phsm
15. Nuzzo JB, Bell JA, Cameron EE. Suboptimal US response to COVID-19 despite robust capabilities and resources. JAMA. 2020;324:1391–2. https://doi.org/10.1001/jama.2020.17395
16. Arsalan M, Mubin O, Alnajjar F, Alsinglawi B, Zaki N. Global and temporal COVID-19 risk evaluation. Front Public Health. 2020;8:440. https://doi.org/10.3389/fpubh.2020.00440
17. Miralles O, Sanchez-Rodriguez D, Marco E, Annweiler C, Baztan A, Betancor É, et al. Unmet needs, health policies, and actions during the COVID-19 pandemic: a report from six European countries. Eur Geriatr Med. 2021;12:193–204. https://doi.org/10.1007/s41999-020-00415-x
18. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. https://doi.org/10.1136/bmj.n71
19. World Health Organization. WHO COVID-19 research database [cited 2021 Jun 2]. https://search.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov
20. xQSR International Pty Ltd. NVivo [cited 2021 Jun 2]. https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home
21. Forman J. Damschroder L. Empirical methods for bioethics: a primer. Bingley (UK): Emerald Group Publishing Limited; 2007.
22. International Association of National Public Health Institutes. Framework for NPHI development [cited 2021 Jun 2]. https://ianphi.org/tools-resources/nphi-framework.html
23. Norwegian Institute of Public Health (NIPH). Map of COVID-19 evidence. June 28, 2021 [cited 2021 Jun 2]. https://www.fhi.no/en/qk/systematic-reviews-hta/map
24. International Association of National Public Health Institutes. 2020 IANPHI progress report [cited 2021 Jun 2]. https://www.ianphi.org/news/2021/2020-progress-report.html
25. Jakab Z, Selbie D, Squires N, Mustafa S, Saikat S. Building the evidence base for global health policy: the need to strengthen institutional networks, geographical representation and global collaboration. BMJ Glob Health. 2021;6:e006852. https://doi.org/10.1136/bmjgh-2021-006852
26. Binder S, Ario AR, Hien H, Mayet N, Jani IV, Ihekweazu C, et al. African national public health institutes responses to COVID-19: innovations, systems changes, and challenges. Health Secur. 2021;19:498–507. https://doi.org/10.1089/hs.2021.0094

Address for correspondence: Alexandra Zuber, Ata Health Strategies LLC, 1537 D St NE, Washington, DC 20003, USA; email: alexandrazuber@atahealthstrategies.com

Article DOI: https://doi.org/10.3201/eid2813.220760

Exploratory Literature Review of the Role of National Public Health Institutes in COVID-19 Response

Appendix 1

Full list of articles reviewed and cited in the manuscript

1. Ding J, Tuan WJ, Temte JL. Managing close contacts of COVID-19 confirmed cases in metropolitan areas in China. J Public Health Manag Pract. 2020;26:345–8. PubMed https://doi.org/10.1097/PHH.0000000000001189

2. Del Manso M, Andrianou X, Urdiales AM, Vescio MF, Rota MC, Fabiani M, et al.; Gruppo Referenti regionali della Sorveglianza Integrata COVID-19. La sorveglianza integrata Covid-19 in Italia: output e attività correlate [COVID-19 integrated surveillance in Italy: outputs and related activities]. Epidemiol Prev. 2020;44(Suppl 2):70–80. PubMed

3. Radio Diez de Marzo. No es la primera vez que Colombia usa los modelos matemáticos en una epidemia. [This is not the first time that Colombia has used mathematical models in an epidemic] [cited 2021 Jun 2]. https://radiodiezdemarzo.com/no-es-la-primera-vez-que-colombia-usa-los-modelos-matematicos-en-una-epidemia-directora-del-ins

4. National Collaborating Centre for Infectious Diseases (NCCID). PHAC models on COVID-19 [cited 2021 Jun 2]. https://nccid.ca/phac-modelling

5. Barcellos C. Uma nova geografia e o direito à informação e comunicação: a sobrevida em meio à pandemia de Covid-19 [A new geography and the right to information and communication: survival in the midst of the Covid-19 pandemic]. Revista Eletrônica de Comunicação, Informação & Inovação em Saúde. 2020;14 [cited 2021 Jun 2]. https://www.reciis.icict.fiocruz.br/index.php/reciis/article/view/2122

6. Korea Disease Control and Prevention Agency (KDCA). COVID-19 response, Republic of Korea [cited 2021 Jun 2]. http://ncov.mohw.go.kr/en/baroView.do?brdId=11&brdGubun=111&dataGubun=&ncvContSeq=&contSeq=&board_id=&gubun=

7. Ethiopian Public Health Institute (EPHI). EPHI PHEOC COVID-19 [cited 2021 Jun 2]. https://ephi.gov.et/download/ephi-pheoc-covid-19

8. Pakistan Council for Science and Technology (PCST). PCST – Coronavirus Knowledge Centre [cited 2021 Jun 2]. https://www.pcst.org.pk/coronavirus_knowledge_center.php

9. Government of Canada. National case definition: Coronavirus disease (COVID-19) [cited 2021 Jun 2]. https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/health-professionals/national-case-definition.html

10. Public Health Center (PHC) of Ukraine. COVID-19, case definition [cited 2021 Jun 2]. https://covid19.phc.org.ua/viznachennya-vipadku

11. Lee D, Choi B. Policies and innovations to battle Covid-19—a case study of South Korea. Health Policy Technol. 2020;9:587–97. PubMed https://doi.org/10.1016/j.hlpt.2020.08.010

12. Kim I, Lee J, Lee J, Shin E, Chu C, Lee SK. KCDC risk assessments on the initial phase of the COVID-19 outbreak in Korea. Osong Public Health Res Perspect. 2020;11:67–73. PubMed https://doi.org/10.24171/j.phrp.2020.11.2.02

13. Umair M, Ikram A, Salman M, Khurshid A, Alam M, Badar N, et al. Whole-genome sequencing of SARS-CoV-2 reveals the detection of G614 variant in Pakistan. PLoS One. 2021;16:e0248371. PubMed https://doi.org/10.1371/journal.pone.0248371

14. Tanzania National Institute for Medical Research (NIMR). Advancing health research, enhancing life [cited 2021 Jun 2]. http://www.nimr.or.tz

15. Lim J, Lee J. Current laboratory diagnosis of coronavirus disease 2019. Korean J Intern Med (Korean Assoc Intern Med). 2020;35:741–8. PubMed https://doi.org/10.3904/kjim.2020.257

16. Jung Y, Park GS, Moon JH, Ku K, Beak SH, Lee CS, et al. Comparative analysis of primer-probe sets for RT-qPCR of COVID-19 causative virus (SARS-CoV-2). ACS Infect Dis. 2020;6:2513–23. PubMed https://doi.org/10.1021/acsinfecdis.0c00464

17. Muhammad A, Owais M, Ali N, Khan H. COVID-19 pandemic and precautionary measures in Pakistan. Anaesth Pain Intensive Care. 2020;24:94–100.. https://doi.org/10.35975/apic.v24i1.1231

18. Cohen J. The United States badly bungled coronavirus testing—but things may soon improve. Science Magazine 2020 [cited 2021 Jun 2]. https://pesquisa.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/pt/covidwho-2779

19. Badar N, Ikram A, Mirza HA, Ahad A, Alam MM, Arshad Y, et al. Laboratory based surveillance of SARS-CoV-2 in Pakistan. medrxiv.org 2020 Jun 20; https://doi.org/10.1101/2020.06.10.20126847

20. Istituto Superiore di Sanità (ISS). Notiziario, Special Issue: ISS for COVID-19 Vol. 33 [cited 2021 Jun 2]. https://www.iss.it/web/iss-en/notiziario/-/asset_publisher/ATfPbffqTz2N/content/id/5510001

21. Government of Pakistan. Pakistan Preparedness & Response Plan COVID-19. April 24, 2020. [cited 2021 Jun 2]. https://reliefweb.int/report/pakistan/pakistan-preparedness-response-plan-covid-19

22. Abera A, Belay H, Zewude A, Gidey B, Nega D, Dufera B, et al. Establishment of COVID-19 testing laboratory in resource-limited settings: challenges and prospects reported from Ethiopia. Dec 31;13(1). [cited 2021 Jun 2]. https://www.tandfonline.com/doi/abs/10.1080/16549716.2020.1841963

23. Kang YJ. Characteristics of the COVID-19 outbreak in Korea from the mass infection perspective. J Prev Med Public Health. 2020;53:168–70. PubMed https://doi.org/10.3961/jpmph.20.072

24. World Health Organization. Novel coronavirus—Thailand. January 14, 2020. [cited 2021 Jun 2]. https://www.who.int/emergencies/disease-outbreak-news/item/2020-DON234

25. World Health Organization. Novel coronavirus—Republic of Korea. January 14, 2020. [cited 2021 Jun 2]. https://www.who.int/emergencies/disease-outbreak-news/item/2020-DON238

26. Rosa MFF, da Silva EN, Pacheco C, Diógenes MVP, Millett C, Gadelha CAG, et al. Direct from the COVID-19 crisis: research and innovation sparks in Brazil. Health Res Policy Syst. 2021;19:10. PubMed https://doi.org/10.1186/s12961-020-00674-x

27. Hong KH, Lee SW, Kim TS, Huh HJ, Lee J, Kim SY, et al. Guidelines for laboratory diagnosis of coronavirus disease 2019 (COVID-19) in Korea. Ann Lab Med. 2020;40:351–60. PubMed https://doi.org/10.3343/alm.2020.40.5.351

28. Espitia-Almeida F, Pereira-Lentino R, Quintero-Soto J, Gómez-Camargo D. Covid-19 in Cartagena and the Bolívar Department, Colombia. Current status, perspectives and challenges until the arrival of the vaccine. Heliyon. 2021;7:e06336. PubMed https://doi.org/10.1016/j.heliyon.2021.e06336

29. Kang J, Jang YY, Kim J, Han SH, Lee KR, Kim M, et al. South Korea's responses to stop the COVID-19 pandemic. Am J Infect Control. 2020;48:1080–6. PubMed https://doi.org/10.1016/j.ajic.2020.06.003

30. Health Canada and PHAC (@GovCanHealth). Any passengers travelling to Canada who have been in the United Kingdom, South Africa or Brazil in the previous 14 days will be subject to secondary screening and increased scrutiny of quarantine plans. Learn more about quarantine planning here: http://ow.ly/gPnW50DaO5f. Posted January 17, 2021 [cited 2021 Jun 2]. https://twitter.com/GovCanHealth/status/1350909521615577089

31. Issac A, Stephen S, Jacob J, Vr V, Radhakrishnan RV, Krishnan N, et al. The pandemic league of COVID-19: Korea versus the United States, with lessons for the entire world. J Prev Med Public Health. 2020;53:228–32. https://doi.org/10.3961/jpmph.20.166

32. Dollard P, Griffin I, Berro A, Cohen NJ, Singler K, Haber Y, et al.; CDC COVID-19 Port of Entry Team. Risk assessment and management of COVID-19 among travelers arriving at designated U.S. Airports, January 17–September 13, 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1681–5. PubMed https://doi.org/10.15585/mmwr.mm6945a4

33. de Lusignan S, Lopez Bernal J, Byford R, Amirthalingam G, Ferreira F, Akinyemi O, et al. Influenza and respiratory virus surveillance, vaccine uptake, and effectiveness at a time of cocirculating COVID-19: protocol for the English primary care sentinel system for 2020–2021. JMIR Publications 2021;7(2). [cited 2021 Jun 2]. http://publichealth.jmir.org/2021/2/e24341

34. US Embassy in Liberia. Alert: U.S. Embassy Monrovia. August 8, 2020 [cited 2021 Jun 2]. https://lr.usembassy.gov/alert-u-s-embassy-monrovia-august-8-2020

35. Junaidi I. Covid-19 can spread rapidly in winter: NIH - Pakistan Dawn.com. October 8, 2020 [cited 2021 Jun 2].https://www.dawn.com/news/1583789

36. Kang H, Kwon S, Kim E. COVID-19 health system response monitor: Republic of Korea. World Health Organization Regional Office for South-East Asia. 2020. [cited 2021 Jun 2].https://apps.who.int/iris/handle/10665/337371

37. Kim JE, Lee JH, Lee H, Moon SJ, Nam EW. COVID-19 screening center models in South Korea. J Public Health Policy. 2021;42:15–26. PubMed https://doi.org/10.1057/s41271-020-00258-7

38. Partners In Health. PIH Liberia, government partners establish New COVID-19 center. June 2020 [cited 2021 Jun 2]. https://www.pih.org/article/pih-liberia-government-partners-establish-new-covid-19-center

39. World Health Organization. Jordan meets increasing demand for mental health and psychosocial support services during the COVID-19 pandemic through planning and collaboration [cited 2021 Jun 2]. http://www.emro.who.int/ar/mnh/news/jordan-meets-increasing-demand-for-mental-

health-and-psychosocial-support-services-during-the-covid-19-pandemic-through-planning-and-collaboration.html

40. Hong L, Hernandez J. Lessons from abroad: Taiwan's COVID-19 containment model APO.org. May 2020 [cited 2021 Jun 2]. https://apo.org.au/node/303792

41. Markus I, Steffen G, Lachmann R, Marquis A, Schneider T, Tomczyk S, et al. COVID-19: cross-border contact tracing in Germany, February to April 2020. Euro Surveill. 2021;26:1–9. PubMed https://doi.org/10.2807/1560-7917.ES.2021.26.10.2001236

42. Omaka-Amari LN, Aleke CO, Obande-Ogbuinya NE, Ngwakwe PC, Nwankwo O, Afoke EN. Coronavirus (COVID-19) pandemic in Nigeria: preventive and control challenges within the first two months of outbreak. Afr J Reprod Health. 2020;24(s1):87–97. PubMed

43. MedicalBrief. Killer disease stumps Nigeria Centre for Disease Control. February 12, 2020 [cited 2021 Jun 2]. https://www.medicalbrief.co.za/killer-disease-stumps-nigeria-centre-for-disease-control

44. Dirlikov E, Fechter-Leggett E, Thorne SL, Worrell CM, Smith-Grant JC, Chang J, et al.; CDC COVID-19 State, Tribal, Local, and Territorial Response Team. CDC Deployments to state, tribal, local, and territorial health departments for COVID-19 Emergency Public Health Response—United States, January 21–July 25, 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1398–403. PubMed https://doi.org/10.15585/mmwr.mm6939a3

45. Oswaldo Cruz Foundation (Fiocruz). Covid-19 observatory [cited 2021 Jun 2]. https://portal.fiocruz.br/observatorio-covid-19

46. Instituto Nacional de Salud Colombia (INS). @INSColombia realizó taller con entidades territoriales para desarrollar capacidades diagnósticas para #COVID-19 #coronavirus. Posted March 17, 2020 [cited 2021 Jun 2]. https://www.facebook.com/INSColombia/posts/3366291743400291

47. de Souza CTV, de Santana CS, Ferreira P, Nunes JA, Teixeira M LB. da Silveira Gouvêa MIF. Caring in the age of COVID-19: lessons from science and society. Cad Saude Publica. 2020;36:6. https://pubmed.ncbi.nlm.nih.gov/32609168/.

48. Marten R, El-Jardali F, Hafeez A, Hanefeld J, Leung GM, Ghaffar A. Co-producing the covid-19 response in Germany, Hong Kong, Lebanon, and Pakistan. BMJ. 2021;372:n243. PubMed https://doi.org/10.1136/bmj.n243

49. Health Canada and PHAC (@GovCanHealth). The #GoC has mobilized Canada's research and scientific communities in response to #COVID19. Read our research response to covid-19 report

to learn more: http://ow.ly/5Qv650zmQDE. Posted April 24, 2020 [cited 2021 Jun 2]. https://twitter.com/GovCanHealth/status/1253745737944436738

50. Fretheim A, Brurberg KG, Forland F. Rapid reviews for rapid decision-making during the coronavirus disease (COVID-19) pandemic, Norway, 2020. Euro Surveill. 2020;25:1. PubMed https://doi.org/10.2807/1560-7917.ES.2020.25.19.2000687

51. Norwegian Institute of Public Health (NIPH). Map of COVID-19 evidence. June 28, 2021 [cited 2021 Jun 2]. https://www.fhi.no/en/qk/systematic-reviews-hta/map

52. Alcaldía de Santiago de Cali. Instituto Nacional de Salud inicia en Cali estudio de seroprevalencia de covid-19 [National Institute of Health begins in Cali covid-19 seroprevalence study]. November 16, 2020 [cited 2021 Jun 2]. https://www.cali.gov.co/salud/publicaciones/157429/instituto-nacional-de-salud-inicia-en-cali-estudio-de-seroprevalencia-de-covid-19

53. United Nations Jordan. WHO continues supporting Jordan's Ministry of Health response to COVID-19. March 28, 2021 [cited 2021 Jun 2]. https://jordan.un.org/en/123437-who-continues-supporting-jordans-ministry-health-response-covid-19

54. Korea Disease Control and Prevention Agency (KDCA). | :
[Clinical trials | Infectious disease: Korea Centers for Disease Control and Prevention] [cited 2021 Jun 2]. https://tinyurl.com/eyp9a8b5

55. Public Health Agency of Canada (PHAC). Preliminary dataset on confirmed cases of COVID-19. August 12, 2022 [cited 2021 Jun 2]. https://www150.statcan.gc.ca/n1/pub/13-26-0003/132600032020001-eng.htm

56. Korea Disease Control and Prevention Agency (KDCA). -19 -
[Coronavirus Infectious Disease-19—Press releases] [cited 2021 Jun 2]. http://ncov.mohw.go.kr/tcmBoardList.do?brdId=3&brdGubun=31&dataGubun=&ncvContSeq=&contSeq=&board_id=&gubun

57. Sarpatwari A, Kaltenboeck A, Kesselheim AS. Missed opportunities on emergency remdesivir use. JAMA. 2020;324:331–2. PubMed https://doi.org/10.1001/jama.2020.11932

58. Abiertos D. Casos positivos de COVID-19 en Colombia [cited 2021 Jun 2]. https://www.datos.gov.co/Salud-y-Protecci-n-Social/Casos-positivos-de-COVID-19-en-Colombia/gt2j-8ykr/data

59. Catholic News Agency (CNA). Catholic and Orthodox Churches in Ukraine consider how to distribute Communion. March 13, 2020 [cited 2021 Jun 2].

https://www.catholicnewsagency.com/news/43857/catholic-and-orthodox-churches-in-ukraine-consider-how-to-distribute-communion

60. Public Health Center (PHC) of Ukraine. Сьогодні в. о. генерального директора ЦГЗ Ігор Кузін та начальник відділу управління проектами та міжнародної співпраці Ольга Гвоздецька зустрілися з Митрополит Епіфаній та архієпископом Чернігівським і Ніжинським Євстратієм. Під час зустрічі представники обговорили актуальну епідеміологічну ситуацію в Україні та світі, протидію пандемії COVID-19, зокрема, завдяки вакцинації. Сторони обговорили співпрацю та взаємодію Центру громадського здоров‘я й Православна Церква України. Зокрема, домовилися про продовження популяризації протиепідемічних заходів у релігійних організаціях та дотримання правил у храмах — носіння маски, респіраторна гігієна та гігієна рук, фізична дистанція. Додатково обговорювалося питання вакцинації проти COVID-19 та поширення достовірної інформації серед вірян. Зокрема, для цього Центр і Церква спільно будуть розробляти низку інформаційних матеріалів для прихожан храмів. Posted January 28, 2021 [cited 2021 Jun 2]. https://www.facebook.com/phc.org.ua/posts/2594515074006538?comment_id=2595429240581788

61. The International Association of National Public Health Institutes (IANPHI). IANPHI progress report – 2020. April 22, 2021 [cited 2021 Jun 2]. https://www.ianphi.org/news/2021/2020-progress-report.html

62. Public Health Agency of Canada (PHAC) twitter account (@GovCanHealth) [cited 2021 Jun 2]. https://twitter.com/GovCanHealth

63. Sallam M, Dababseh D, Yaseen A, Al-Haidar A, Ababneh NA, Bakri FG, et al. Conspiracy beliefs are associated with lower knowledge and higher anxiety levels regarding COVID-19 among students at the University of Jordan. Int J Environ Res Public Health. 2020;17:4915.

64. Istituto Superiore di Sanità. COVID-19 integrated surveillance: key national data—EpiCentro March 11, 2020 [cited 2021 Jun 2]. https://www.epicentro.iss.it/en/coronavirus/sars-cov-2-integrated-surveillance-data

65. Instituto Nacional de Salud (INS) Instituto Nacional de Salud twitter account (@INSColombia) [cited 2021 Jun 2]. https://twitter.com/inscolombia

66. National Institute of Health (NIH) Pakistan NIH Pakistan twitter account (@NIH_Pakistan) [cited 2021 Jun 2]. https://twitter.com/NIH_Pakistan

67. National Public Health Institute of Liberia (NPHIL). National Public Health Institute of Liberia twitter account (@NPHIL6) [cited 2021 Jun 2]. https://twitter.com/nphil6

68. Miralles O, Sanchez-Rodriguez D, Marco E, Annweiler C, Baztan A, Betancor É, et al. Unmet needs, health policies, and actions during the COVID-19 pandemic: a report from six European countries. Eur Geriatr Med. 2021;12:193–204. PubMed https://doi.org/10.1007/s41999-020-00415-x

69. Coronado F, Blough S, Bergeron D, Proia K, Sauber-Schatz E, Beltran M, et al. Implementing mitigation strategies in early care and education settings for prevention of SARS-CoV-2 transmission—eight states, September–October 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1868–72. PubMed https://doi.org/10.15585/mmwr.mm6949e3

70. Jeong GH, Lee HJ, Lee J, Lee JY, Lee KH, Han YJ, et al. Effective control of COVID-19 in South Korea: cross-sectional study of epidemiological data. J Med Internet Res. 2020;22:e22103. PubMed https://doi.org/10.2196/22103

71. Marques F. Fiocruz News Agency Oswaldo Cruz Foundation (Fiocruz). November 5, 2020 [cited 2021 Jun 2]. https://agencia.fiocruz.br/alimentacao-na-pandemia-e-o-tema-do-conexao-fiocruz-brasilia

72. Kuhn A. South Korea faces new spike in COVID-19 after months of low infection rates NPR.com. August 17, 2020 [cited 2021 Jun 2]. https://www.npr.org/sections/coronavirus-live-updates/2020/08/17/903157458/south-korea-faces-new-spike-in-covid-19-after-months-of-low-infection-rates

73. Public Health Center (PHC) of Ukraine. Ukraine has submitted the first part of the application for a vaccine against COVID-19 Center for public health. December 8, 2020 [cited 2021 Jun 2]. https://phc.org.ua/news/ukraina-podala-pershu-chastinu-zayavki-na-otrimannya-vakcini-vid-covid-19

74. Infobae. Instituto Nacional de Salud alerta sobre la “tormenta perfecta” que sería el covid-19 durante la Semana Santa en Colombia—Infobae. March 26, 2021 [cited 2021 Jun 2]. https://www.infobae.com/america/colombia/2021/03/26/instituto-nacional-de-salud-alerta-sobre-la-tormenta-perfecta-que-seria-el-covid-19-durante-la-semana-santa-en-colombia

75. Paton N. Managing Covid-19 “clusters” set to be a key challenge for occupational health—Personnel Today. Occupational Health & Wellbeing Plus. October 2, 2020 [cited 2021 Jun 2].

https://www.personneltoday.com/hr/managing-covid-19-clusters-set-to-be-a-key-challenge-for-occupational-health

76. Tagliacozzo S, Albrecht F, Ganapati NE. International perspectives on COVID-19 communication ecologies: public health agencies' online communication in Italy, Sweden, and the United States. Am Behav Sci. 2021;65:934–55. https://doi.org/10.1177/0002764221992832

77. Apuke OD, Bahiyah O. How do Nigerian newspapers report COVID-19 pandemic? The implication for awareness and prevention. Health Educ Res. 2020;35:471–80 [cited 2021 Jun 2]. https://academic.oup.com/her/article-abstract/35/5/471/5935539

78. Mboya IB, Ngocho JS, Mgongo M, Samu LP, Pyuza JJ, Amour C, et al. Community engagement in COVID-19 prevention: experiences from Kilimanjaro region, northern Tanzania. Pan Afr Med J. 2020;35(Suppl 2):146. PubMed https://doi.org/10.11604/pamj.supp.2020.35.2.24473

79. Song R, Kim HS, Yoo SJ, Lee K, Park JH, Jang JH, et al. COVID-19 in nursing facilities: experience in Republic of Korea. Osong Public Health Res Perspect. 2020;11:164–9. PubMed https://doi.org/10.24171/j.phrp.2020.11.4.04

80. Oswaldo Cruz Foundation (Fiocruz). UNITED AGAINST COVID-19 [cited 2021 Jun 2]. https://unidos.fiocruz.br/index-en.html

81. Kang YJ. Lessons learned from cases of COVID-19 infection in South Korea. Disaster Med Public Health Prep. 2020;14:818–25. PubMed https://doi.org/10.1017/dmp.2020.141

82. United Nations Population Fund. Learning from Ebola experience, Liberia deploys contact tracers to break COVID-19 transmission. Africa Renewal. April 24, 2020 [cited 2021 Jun 2]. https://www.un.org/africarenewal/news/learning-ebola-experience-liberia-deploys-contact-tracers-break-covid-19-transmission

83. Last Mile Health. COVID-19 response [cited 2021 Jun 2]. https://lastmilehealth.org/what-we-do/covid-19-response

84. Devex. National Public Health Institute of Liberia (NPHIL) [cited 2021 Jun 2]. https://www.devex.com/organizations/national-public-health-institute-of-liberia-nphil-132858

85. Hur JY, Kim KW. Crisis learning and flattening the curve: South Korea's rapid and massive diagnosis of the COVID-19 infection. Am Rev Public Adm. 2020;50:606–13. https://doi.org/10.1177/0275074020941733

86. Sung H, Yoo CK, Han MG, Lee SW, Lee H, Chun S, et al. Preparedness and rapid implementation of external quality assessment helped quickly increase COVID-19 testing capacity in the Republic of Korea. Clin Chem. 2020;66:979–81. PubMed https://doi.org/10.1093/clinchem/hvaa097

87. Bhutta ZA, Sultan F, Ikram A, Haider A, Hafeez A, Islam M. Balancing science and public policy in Pakistan's COVID-19 response. East Mediterr Health J. 2021;27:798–805. PubMed https://doi.org/10.26719/emhj.21.016

88. The Aga Khan University. News [cited 2021 Jun 2]. https://www.aku.edu/news/Pages/home.aspx

89. World Health Organization. Nurses and midwives are critical to teaching hand hygiene in Pakistan. May 4, 2020 [cited 2021 Jun 2]. https://www.who.int/news-room/feature-stories/detail/nurses-and-midwives-are-critical-to-teaching-hand-hygiene-in-pakistan

90. The Public Health Agency of Canada (PHAC). COVID-19 - Free contact tracing training opportunities. 2020 [cited 2021 Jun 2]. http://www.afn.ca/wp-content/uploads/2020/10/CoronaVirus_Free__Contact_Tracing_ENG.pdf

91. Gerrard A. A coordinated public-private sector response in Liberia to COVID-19 Health Policy Plus [cited 2021 Jun 2]. http://www.healthpolicyplus.com/liberiaHFL.cfm

92. Petrini C, D'Aprile C, Floridia G, Gainotti S, Riva L, Tamiozzo S. Protection of individual and collective health: ethical-legal issues and opportunities for public health after COVID-19 [cited 2021 Jun 2]. https://pesquisa.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/pt/covidwho-1139101

93. Oswaldo Cruz Foundation (Fiocruz). Recomendações para o Método Canguru Durante a Pandemia de COVID-19 Portal of Good Practices in Women's, Children's and Adolescents' Health. March 2020 [cited 2021 Jun 2]. https://portaldeboaspraticas.iff.fiocruz.br/biblioteca/recomendacoes-para-o-metodo-canguru-durante-a-pandemia-de-covid-19

94. Kim EY, Kim EK, Lee M, Park HK. COVID-19 public health measures during national assembly elections of the Republic of Korea. Osong Public Health Res Perspect. 2020;11:158–63. PubMed https://doi.org/10.24171/j.phrp.2020.11.4.03

95. Song R, Choi YS, Ko JY. Operating a national hotline in Korea during the COVID-19 pandemic. Osong Public Health Res Perspect. 2020;11:380–2. PubMed https://doi.org/10.24171/j.phrp.2020.11.6.06

96. Andersson S, Aylott N. Sweden and coronavirus: unexceptional exceptionalism. Soc Sci. 2020;9:232. https://doi.org/10.3390/socsci9120232

97. Onalu CE, Chukwu NE, Okoye UO. COVID-19 response and social work education in Nigeria: Matters arising. Soc Work Educ. 2020;39:1037–47. https://doi.org/10.1080/02615479.2020.1825663

98. Bledsoe M, Captanian A. research ASJ of safety, 2021 undefined. Special report from the CDC: strengthening social connections to prevent suicide and adverse childhood experiences (ACEs): actions and opportunities. J Safety Res. 2021;77:328–33. PubMed https://doi.org/10.1016/j.jsr.2021.03.014

99. Kesselheim AS, Darrow JJ, Kulldorff M, Brown BL, Mitra-Majumdar M, Lee CC, et al. An overview of vaccine development, approval, and regulation, with implications For COVID-19. Health Aff (Millwood). 2021;40:25–32. **PMID: 33211535**

100. Zhang Y, Shi L, Chen H, Wang X, Sun G. Policy disparities in response to the first wave of COVID-19 between China and Germany. Int J Equity Health. 2021;20:86. PubMed https://doi.org/10.1186/s12939-021-01424-3

Article DOI: https://doi.org/10.3201/eid2813.220760

Exploratory Literature Review of the Role of National Public Health Institutes in COVID-19 Response

Appendix

Methods Summary

Data collection

Our descriptive literature review aimed to characterize the role of NPHIs in COVID-19 and identify any gaps in the literature on this subject. The review was not a systematic review, but did follow many PRISMA checklist practices. Our research team comprised three researchers. Our methods included an electronic database search of peer-reviewed articles (Appendix Table 4) and gray articles, as well as search for gray reports. We conducted our electronic database search using the WHO COVID-19 Global Research Database. We selected the WHO COVID-19 Global Research Database due to its comprehensive inclusion of articles from multiple electronic databases, and its focus on articles pertaining to COVID-19.

In the WHO COVID-19 Global Research Database, we conducted several consecutive searches. The first search used the terms “national public health institute,” with a filter of “title, abstract, or subject”. No other filters were used, such as to narrow by language, database, or period of publication. We then established a sample frame of NPHIs to represent a majority of NPHIs in the world. We categorized all IANPHI members (n=111) by their country’s position on four World Bank income levels (i.e., high, upper middle, lower middle, and low income) and six World Bank regions. We then purposely selected two to three NPHIs per tier from each of the six regions, which resulted in 61 NPHIs selected. We selected NPHIs in the pattern we felt balanced geography and income levels most equally. The NPHIs represented 52 countries because some countries have more than one IANPHI member.

We then conducted 61 consecutive discrete searches each using the proper name of the NPHIs, in English and in the official language of its host country, as listed on the IANPHI

website. The same filter of “title, abstract, or subject” was used for each of these searches, and no others. The period for these searches was March 19-23, 2021 (search term “NPHI”) and May 3-7, 2022 (proper name searches). One researcher conducted the name-based search and suggested articles for inclusion in three categories: yes, no, or maybe. The senior author then reviewed all categories and the two decided together on a call the articles for inclusion and exclusion.

Our inclusion criteria (summarized in Appendix Table 2) was that the article had the search term in the title or abstract of the article, described the role of the NPHI or NPHIs in responding to COVID-19, had as a study context one of the 61 countries in our sample frame, comprised quantitative or qualitative studies, technical reports, assessments or evaluations, new reports, social media posts, or government websites; and are written in any language. Google Translate was used for languages other than English, French, Arabic, and Portuguese. Our exclusion criteria was publications that did not provide sufficient information on the NPHI’s role, publications that summarized studies that did not include the NPHI as a funder, implementer, or provider of data, and full text documents that were not accessible.

We recognized that because of the early advent of COVID-19, NPHI activities may not yet be documented in the peer-reviewed literature. Therefore, we constructed a gray literature search strategy, to identify reports, assessments, news articles and more that would summarize NPHI activities. For feasibility reasons, we narrowed our gray search sample frame to eight NPHIs (selected from the 61 NPHI sample frame). We selected two NPHIs from each World Bank income tier, with at least one per World Bank region. We aimed to select the list of countries that best represented geographic and income diversity. For example, if we selected a country with 'high -middle' income in one region, we would attempt to select a country with 'low-middle' income in another, so that income characteristics were evenly distributed. Two researchers conducted the gray search, and independently determined inclusion or exclusion of articles based on our common criteria.

Once the study frame was established, we searched Google, as well as the official government websites and social media accounts, of the eight NPHIs. Our Google search terms included the proper name of each of the eight NPHIs in English, as well as in the language of origin, AND “COVID-19.” We included all studies, reports, new articles, and web pages in any

language that described activities conducted by NPHIs as part of the COVID-19 response. We used Google Translate for articles not in English. The same inclusion and exclusion criteria that was used for the electronic search was used for the gray search. The dates for this gray literature search was June 1, 2021- June 8, 2021.

Data Analysis

Articles form the electronic search were imported to NVIVO software (*19*) for qualitative analysis. We utilized a 3-step, evidence-based strategy described by Forman and Damschroeder, 2008. The first step (immersion) included review of the article in its entirety, at times taking any notes or observations in a linked memo in NVIVO. In the second step – "deduction"- the authors conducted "preliminary coding" of each article (and memo where it existed) using the deductive parent codes. Once all articles had been coded by deductive parent codes, the authors then saved a PDF file of each parent "node" report, and conducted secondary coding of each of these reports. The authors identified inductive sub-codes in this process, and coded each report accordingly to those nodes. In the third and final stage – interpretation- the authors opened each of the sub-code reports and discussed findings, developed conclusions, and identified country examples to highlight in the narrative.

For the gray returns, our research pair preferred the use of Microsoft Excel for data management. Given the volume of returns, it was more efficient to cut and paste coded passages to Excel than attempting to import webpages and other online documents to NVIVO. Coding was conducted by two researchers, who were responsible for analysis of four countries each. They reviewed each return in full, then reviewed a second time, cutting and pasting coded passages in the Excel fields under parent and secondary code columns. Passages were further organized by source (with link), country, Google results page number, and date of publication where available. Secondary codes were those identified inductively from the analysis of the electronic search returns. Using column filters, the team was able to quantify the number of returns that cited NPHI activities in each of the parent and secondary codes, and these numbers were consolidated with the numbers determined from NVIVO to complete Table 3.

We used a codebook of deductive and inductive codes. Our conceptual framework was the IANPHI Essential Public Health Functions framework (*23*). This framework describes 11 "core" public health functions supported by NPHIs, which we used as our deductive codes to

categorize NPHI activities in the COVID-19 response. We relied on the definitions provided by IANPHI for these functions to support inter-rater reliability. No other deductive codes were used. We established coding agreement by having each review pair, of which there were two, independently code two returns, compare coding passages and discuss and resolve differences in interpretation.

Because this was a descriptive and not a systematic review or meta-analysis, we did not feel it was appropriate to evaluate the quality of the articles. The articles we identified were of sufficient diversity in type and content, rendering quality scoring impossible. However, each of three reviewers was asked to assess the "relevance" of the article findings to the study topic for each of the peer-reviewed articles. This data, along with a summary of key related findings of each article, is included as a table appended to the manuscript.

Data visualization

The authors took select steps to visualize the data generated. First, one researcher established a table of the countries that were searched and the countries that had articles included in the review, and converted this data into a color-coded map. The authors also used NVIVO data to quantify the number of articles that cited at least one activity in a particular parent code, and assembled this tabulation in a table appended to the manuscript. This table summarizes the total number of articles that cite NPHI activities, by each of 11 essential public health functions.

Appendix Table 1. Search terms

Method	Database	Search terms	Dates
Electronic database search	WHO COVID-19	"national public health institute"	May 26, 2021
	WHO COVID-19	Proper name of NPHIs in 61 countries in English and then in the language of origin (Table)	May 26[h] and August 1, 2021
Search of the gray literature	Google	For 8 select NPHIs, applied proper name of the NPHI in English OR the language of origin AND COVID-19	June 1st, 2021 to June 8th, 2021
	NPHI websites, Twitter & Facebook	For 8 select NPHIs, conducted hand-search for articles, reports, or news stories describing activities of one of eight select NPHIs the COVID-19 response. Facebook posts from January 2020 to March 2021 were reviewed.	June 1st, 2021 to June 8th, 2021

Appendix Table 2. Inclusion and exclusion criteria for screened articles

Type of criteria	Specific criteria
Inclusion criteria	
	Have the search term in the title or abstract of the article. Describe the role of the NPHI or NPHIs in responding to COVID-19. Study context is one of the 61 countries of focus for our review. Comprised quantitative or qualitative studies, technical reports, assessments or evaluations, news reports, social media posts, or government websites. Are written in any language; Google Translate was used for languages other than English, French, Arabic, and Portuguese.
Exclusion criteria:	
	Publications that did not provide sufficient information on the NPHI's role Publications that summarized studies that did not include the NPHI as a funder, implementer, or provider of data. Full text documents are not accessible

Appendix Table 3. Articles included in the review that document an NPHI's role in the COVID-19 response by IANPHI Core Public Health Function

IANPHI Public Health Functions	No. of returns from the electronic database search	No. of returns from the search of websites and social media
1. Evaluation and analysis of health status	4	3
2. Public health surveillance, problem investigation, and control of risks and threats to public health	30	53
3. Prevention programs and health promotion	24	32
4. Social participation in health	7	13
5. Planning and management	7	4
6. Regulation and enforcement	5	4
7. Evaluation and promotion of coverage and access to health services	3	5
8. Human resource development and training	6	0
9. Quality assurance in personal and population -based health services	11	6
10. Public health research	10	7
11. Reduction of the impact of emergencies and disasters on health	5	10

*A single article may refer to more than one function, so the total of each column is over the total number of articles reviewed.

Appendix Table 4. Peer-reviewed articles from the literature review of the role of NPHIs in the COVID-19 response

			Quality assessment	
Reference	Country	Relevant findings	Type of reference	Relevance
(De Lusignan et al., 2021) (*1*)		Throughout the paper, the authors mention and describe the linkage with Public Health England (PHE). PHE is described as conducting surveillance and research activities. Within the surveillance function, PHE has the lab capacity to collect self-administered COVID-19 swabs and analyze them to provide results. PHE is also a member of I-MOVE (Influenza–Monitoring Vaccine Effectiveness in Europe) consortium for monitoring influenza vaccine effectiveness in Europe.	Peer reviewed article	Medium
(Del Manso et al., 2020) (*2*)	Italy	ISS activities included defining and updating case definitions, data sharing, setting up technology to enhance the data shared, quality and completeness of the data, and integrating COVID-19 reporting to the IDSR. The paper mainly discusses these IANPHI core functions: evaluation and analysis of health status, public health surveillance, problem investigation, and control of risks and threats to public health, social participation in health, and reduction of the impact of emergencies and disasters on health.	Peer reviewed article	High
(Markus et al., 2021) (*3*)	Germany	RKI managed the data sharing between the public authority in Germany and abroad. Cross border contact tracing at the national level is operated by the Robert Koch Institute (RKI), the federal public	Peer reviewed article	Medium

Reference	Country	Relevant findings	Quality assessment	
			Type of reference	Relevance
		health institute in Germany. Besides that, the paper has no additional examples besides a flow chart of information in the context of contact tracing in Germany.		
(Petrini et al., 2020) (*4*)	Italy	The report contains guidance and ethical considerations after the COVID-19 pandemic geared towards understanding the "Bioethical aspects" that the general practitioner faces when treating patients, family, and the community, Family nurses, telemedicine, the reform of the electronic health records, delayed care due to the pandemic and lockdowns, the right to health, protection of vulnerable populations, palliative care, and contact tracing.	Report	Low
(Espitia-Almeida et al., 2021) (*5*)	Colombia	The INS was the regulation body that gave approvals to approve COVID-19 samples. The samples in the study were transported from provider institutions (IPS) then to departmental public health labs, then UNIMOL labs (process), then results were updated in a national registry platform. The role of the INS was to process all the results.	Peer reviewed article	High
(Abera et al., 2020) (*6*)	Ethiopia	The EPHI was able to identify a suitable space, mobilize the necessary resources, and train staff. A steering committee was formed by voluntary team members from the Malaria and NTDs research team to lead the laboratory establishment. Some of the lessons learned include: 1) Repurpose existing laboratory spaces using national and WHO guidelines 2) Mobilize underutilized resources such as equipment and human resources for COVID-19 laboratory setup. (particularly equipment available for health research and diagnostics); 3) Collaborate with local and international health experts and equipment manufacturers and agents to solve laboratory issues 4) Ensure that space and equipment identified for COVID-19 testing is sterile and contamination free from the outset. The paper also suggests that university can follow a similar process to establish COVID-19 rapid testing laboratories.	Peer reviewed article	High
(Fretheim et al., 2020) (*7*)	Norway	All reviews are published with explicit messages about the risk of overlooking key evidence or making misguided judgements by using such rapid processes. The NIPH established a rapid review team with a 1 to 3 days turnaround time.	Commentary article	High
(Fiocruz, 2020) (*8*)	Brazil	In Brazil, FIOCRUZ worked with a group of national consultants to produce a report containing recommendations when caring for newborns in the context of COVID-19. The NPHI was involved with research and compiled existing recommendations. Additionally, FOCRUZ set up case definitions.	Report	Low
(K. H. Hong et al., 2020) (*9*)	S. Korea	Korean Society for Laboratory Medicine and the Korea Centers for Disease Prevention and Control proposed guidelines for diagnosing COVID-19 in clinical laboratories in Korea. These guidelines are based on other related domestic and international guidelines, as well as expert opinions and include the selection of test subjects, selection of specimens, diagnostic methods, interpretation of test results, and biosafety.	Peer reviewed article	High
(Hur & Kim, 2020) (*10*)	S. Korea	Crisis learning enabled South Korea to flatten the COVID-19 infection curve—specifically, by applying lessons from both past epidemics and the current outbreak. After the country suffered from 2015 Middle East respiratory syndrome coronavirus (MERS) outbreak, the Korea Centers for Disease Control & Prevention (KCDC), the national disease control agency, improved its surveillance system by establishing a 24-hr Emergency Operation Center (EOC) to collect information about real-time domestic and international infectious diseases. Moreover, the KCDC adopted measures such as emergency use authorization (EUA) to speed up the development and the supply of diagnosis equipment, which enabled qualified private health providers to diagnose cases of the viral infection.	Peer reviewed article	High
(Issac et al., 2020) (*11*)	S. Korea	Korea KDCA developed the mobile application “Corona-100m”, which alerted people who came within 100 meters from places where confirmed cases had been. Additionally, they conducted contact tracing of cases and tested asymptomatic people regardless of their contacts. The transparency of the agency was also mentioned as crucial to the response (media briefings).	Commentary article	High

Reference	Country	Relevant findings	Quality assessment	
			Type of reference	Relevance
(Jeong et al., 2020b) (*12*)	S. Korea	In South Korea, the CDSCHQ is operated by the Ministry of Health and Welfare and Ministry of Public Administration and Security, to support KCDC with its disease control efforts and to provide the necessary assistance in matters requiring coordination between the central government and local municipal governments. A confirmed patient is reported as soon as diagnosed to the provincial government and KCDC immediately.	Peer reviewed article	High
(Y. J. Kang, 2020) (*13*)	S. Korea	The KCDC was able to approve the use of a testing kit and rapidly deploy it to around 50 testing facilities. Other key steps were tracking cases, finding exposed individuals, coordinating case assignments with health care facilities, and selective clinic screenings for visitors' entering hospitals with mandatory mask wearing. Korea KDCA was involved in: updating case definitions, expanding diagnosis testing, tracking exposed cases and isolation of confirmed cases, and treatment, Public messaging	Peer reviewed article	High
(E. Y. Kim et al., 2020) (*14*)	S. Korea	The KCDC personnel coordinated with the government departments related to the election such as the Ministry of the Interior and Safety, local governments, and the National Election Commission. The KCDC established guidelines for COVID-19 patients and individuals isolating at home during the general elections for the 21st National Assembly.	Peer reviewed article	High
(I. Kim et al., 2020) (*15*)	S. Korea	The KDCA established risk assessment criteria that aimed to provide information to enable evidence-based strategic response planning and relevant response measures for KCDC and the Ministry of Health and Welfare. It provided the risk assessment for COVID-19 at given dates, including the details on travel-associated imported cases, clusters outside Korea, risk for healthcare system capacity, options for preparedness and response, risk communication, social distancing, contact tracing and enhanced surveillance.	Peer reviewed article	High
(D. Lee & Choi, 2020) (*16*)	S. Korea	The KCDC jointly with medical professionals developed a series of innovations such as 1) full contact tracing and rapid testing with a 12 h turnaround and 10 min movement tracking systems, 2) transparent disclosure of all contract tracing data to the public through a central database, 3) drive through and walk- Through testing methods, and 4) a 4-tier patient severity index and community treatment isolation centers. Korea moved from the 4th in the world for total confirmed cases in March down to 76th in August.	Peer reviewed article	High
(Song et al., 2020) (*17*)	S. Korea	The KCDC operated and managed a national hotline, first created during a previous epidemic. The KCDC also engaged in health promotion activities with the participation of EIS staff. In its activities, the KCDC engaged with government ministries and financial investment firms.	Journal article	Low
(Rosa et al., 2021) (*18*)	Brazil	In Brazil, Fiocruz engaged in research related activities in collaboration with universities in the country.	Commentary article	Low
(Song et al., 2020) (*19*)	S. Korea	In Korea, the KCDC's preventive measures guidance is to test all the people who have been in contact with a confirmed COVID-19 case.	Peer reviewed article	High
(de Souza et al., 2020b) (*20*)	Brazil	In Brazil, Fiocruz engaged with community leaders to counter fake information on COVID-19. They used WhatsApp in their methodology.	Journal article	Medium
(Andersson & Aylott, 2020a) (*21*)	Sweden	The Swedish Institute, a public agency that, according to its website, "promotes interest and trust in Sweden around the world". The Swedish institute participated in the planning and management efforts in the country, assessed the risk of COVID-19 infections, and produced guidelines and recommendations. The Agency also recommended social distancing measures and other preventions measures.	Peer reviewed article	Medium
(Onalu et al., 2020) (*22*)	Nigeria	The Nigeria Centre for Disease Control [NCDC] was at the forefront of providing information about the virus and required preventive measures for the public.	Peer reviewed article	Low
(Apuke & Omar, 2020) (*23*)	Nigeria	This study examined media coverage of COVID19 in Nigeria with attention to the frequency and depth of coverage, story format, news sources, media tone and themes. The highest source cited was the NCDC, followed by other government officials, health sector, medical experts (e.g., virologists) and WHO and United Nations. They announce new infectious disease, death rates and any other related cases including COVID-19 infections.	Peer reviewed article	Medium

Reference	Country	Relevant findings	Quality assessment	
			Type of reference	Relevance
(Bledsoe et al., 2021) (*24*)	United States	The US CDC provided guidance for suicide prevention in the context of COVID-19 pandemic (due to self- isolation).	Peer reviewed article	Low
(Coronado, 2020) (*25*)	United States	MMWR report on the implementation of mitigation strategies in education settings. The US CDC played a role of setting guidelines to be implemented. These guidelines were linked to federal funding.	Peer reviewed article	Medium
(Ding et al., 2020) (*26*)	China	The Chinese Center for Disease Control and Prevention (CCDC) has required that all COVID-19 confirmed cases be recorded and documented in a national notifiable disease surveillance system (NDSS). The CCDC also performed surveillance and contact tracing activities. Additionally, the CCDC adopted a community-based approach in contact tracing involving all stakeholders including local public health departments, public safety authorities, neighborhood councils, and community health centers.	Peer reviewed article	Medium
(Dirlikov et al., 2020) (*27*)	United States	MMWR report on the deployment of US CDC staff to subnational level health authorities. After activating the EOC, the US CDC established a dedicated COVID-19 response section to support state, tribal, local, and territorial health departments. The US CDC provided the following assistance: epidemiologic support, infection prevention and control in health care settings, health communications, community mitigation, and occupational safety and health	Peer reviewed article	High
(Dollard et al., 2020) (*28*)	United States	MMWR report on the risk assessment and management of COVID-19 at US airports. The US CDC, in collaboration with the department of homeland security, instituted a screening program for air travelers into the United States. Th US CDC also shared the data with states' health departments to better control the spread of the virus via CDC's Epidemic Information Exchange (Epi-X).	Peer reviewed article	High
(Kesselheim et al., 2021) (*29*)	United States	The US CDC, alongside the FDA takes part in the post approval surveillance and safety system for vaccines. The surveillance is based on the following systems: CDC and FDA Vaccine Adverse Event Reporting System (VAERS), the CDC Vaccine Safety Datalink, and the CDC Clinical Immunization Safety Assessment (CISA) Project.	Peer reviewed article	Medium
(Miralles et al., 2021) (*30*)	Belgium, France, Italy, Poland, Spain, and United Kingdom	The article assesses the impact of policies to decrease the overall impact of the COVID-19 pandemic in Europe on the older population. From the 6 European countries: Belgium, France, Italy, Poland, Spain, and United Kingdom, only one NPHI example was mentioned. Participation in providing information to the public through the use of websites and social media outlets and health promotion activities were portrayed.	Peer reviewed article	Low
(Omaka-Amari et al., 2020) (*31*)	Nigeria	The Nigeria CDC led the activation of the country's EOC, contact tracing, testing, isolation, and providing information to the public about the risks of the spread of the virus.	Peer reviewed article	Low
(Tagliacozzo et al., 2021) (*32*)	Italy, Sweden, United States	This study examines the online communication of national public health agencies during the COVID-19 pandemic in Italy, Sweden, and the United States. NPHIs from these countries took part in intergovernmental efforts to provide information to the public through their social media outlets and collaborated with National NGOs. These NPHIs mainly targeted the general public, businesses, nursing homes, etc.	Peer reviewed article	Medium
(Zhang et al., 2021) (*33*)	China, Germany	This article summarized policy disparities in response to the first wave of COVID-19 between China and Germany. German Federal Center for Disease Control (Robert Koch Institute) assessed the situation of COVID-19 in Germany. The Ministry of health and defense used those assessments to establish a federal-level epidemic response headquarters and developed a series of prevention and control measures.	Peer reviewed article	Low

* Quality assessment was not deemed appropriate for this descriptive review, as our aim was to describe the role of NPHIs in the COVID-19 response using a diverse range of article types and not to compare or contrast the impact of interventions. However, we characterize the literature by documenting their study type, country of focus, their relevant findings, and the degree (high, medium to low) to which they described an NPHIs role in COVID-19 response (i.e. were relevant).

Appendix Table 5. Countries (n = 52) and IANPHI members (n = 61) searched, and the articles identified by country in the electronic database search and search of gray literature

Count	Country	Name of NPHI *(Based on IANPHI member list)*	Acronym	No. of returns included in the electronic database search	No. of articles included in the search of websites, and social media	NPHI Websites searched
1.	Afghanistan	Afghan National Public Health Institute	NPHI	0	*	*
2.	Argentina	Administración Nacional de Laboratorios e Institutos de Salud	ANLIS	0	*	*
3.	Bangladesh	Institute of Epidemiology Disease Control & Research *(IEDCR)*	IEDCR	0	*	*
4.	Brazil	Fundação Oswaldo Cruz	FIOCRUZ	16	*	*
5.	Burkina Faso	Institut National de Sante Publique	INSP	0	*	*
6.	Cambodia	National Institute of Public Health	NIPH	0	*	*
7.	Cameroon	Direction de la Lutte Contre la Maladie, les Epidemies, et les Pandemies	DLM	0	*	*
8.	Canada	Institut National De Santé Publique Du Quebec	INSP	0	41	https://www.canada.ca/en/public*health.html
9.	China	Chinese Center for Disease Control and Prevention	C. CDC	1	*	*
10.	Colombia	Instituto Nacional de Salud	INS	1	52	https://www.ins.gov.co/
11.	Côte D'Ivoire	Institut National de Santé Publique	INSP	0	*	*
12.	Czech Republic	National Institute of Public Health	SZU	0	*	*
13.	Denmark	Statens Institut for Folkesundhed	SIF	0	*	*
		Statens Serum Institut	SSI	0	*	*
14.	Ethiopia	Ethiopian Public Health Institute	EPHI	1	12	https://ephi.gov.et/
15.	Finland	Finnish Institute for Health and Welfare	FIHW	0	*	*
16.	France	Santé Publique France	SPF	0	*	*
17.	Georgia	Georgia National Center for Disease Control and Public Health	NCDC	0	*	*
18.	Germany	Bundeszentrale für gesundheitliche Aufklärung	BZgA	1	*	*
		Robert Koch Institut	RKI		*	*
19.	Ghana	Noguchi Memorial Institute for Medical Research	NMIMR	0	*	*
		Ghana Health Service	GHS	0	*	*
20.	Guatemala	Centro Nacional de Ciencias de la Salud	CNCS	0	*	*
21.	India	National Centre for Disease Control *(formerly National Institute of Communicable Disease)*	NCDC	0	*	*
22.	Iran Islamic Republic	Institute of Public Health Research	IPHR	0	*	*
23.	Italy	Instituto Superiore di Sanità	ISS	3	*	*
24.	Jordan	Ministry of Health	-	0	15	http://www.moh.gov.jo/
25.	Kazakhstan	National Center for Public Healthcare	NCPH	0	*	*
26.	Kenya	Kenya Medical Research Institute	KEMRI	0	*	*
		Kenya National Public Health Institute	KNPHI	0	*	*
27.	Korea, Rep.	Korea Centers for Disease Control and Prevention/ Korea Disease Control and Prevention Agency	KCDC / KDCA	11	67	http://www.kdca.go.kr/

Count	Country	Name of NPHI *(Based on IANPHI member list)*	Acronym	No. of returns included in the electronic database search	No. of articles included in the search of websites, and social media	NPHI Websites searched
28.	Liberia	National Public Health Institute of Liberia	NPHIL	0	20	https://www.nphil.gov.lr/
29.	Malawi	Public Health Institute Malawi	PHIM	0	*	*
30.	Mexico	Instituto Nacional de Salud Publica	INSP	0	*	*
31.	Mongolia	National Center for Public Health	NCPH	0	*	*
32.	Morocco	Institut Pasteur Du Maroc *(IPM)*	IPM	0	*	*
		National Institute of Hygiene	NIH	0	*	*
		Direction of Epidemiology and Control Diseases, Ministry of Health	-	0	*	*
33.	Mozambique	Instituto Nacional de Saúde	INS	0	*	*
34.	Nigeria	Nigerian Institute of Medical Research	NIMR	4	*	*
1.		Nigeria Centre for Disease Control	NCDC		*	*
1.		National Primary Health Care Development Agency	NPHCDA		*	*
35.	Norway	Norwegian Institute of Public Health	NIPH	2	*	*
36.	Pakistan	Pakistan's National Institute of Health	NIH	0	46	https://www.nih.org.pk/
37.	Panama	Instituto Conmemorativo Gorgas de Estudios de la Salud	ICGES	0	*	*
38.	Russian federation	National Research Center for Preventive Medicine	-	0	*	*
39.	Saudi Arabia	Saudi Centre for Disease Control and Prevention	S. CDC	0	*	*
40.	Sierra Leone	Ministry of Health & Sanitation	-	0	*	*
41.	Somalia	National Institute of Health	NIH	0	*	*
42.	South Africa	National Institute for Communicable Diseases	NICD	2	*	*
43.	Sweden	Public Health Agency of Sweden	-	1	*	*
44.	Thailand	National Institute of Health	NIH	1	*	*
45.	Tunisia	Institut National de la Santé Publique	INSP	0	*	*
46.	Turkey	Refik Saydam National Public Health Agency	-	0	*	*
47.	Uganda	Uganda National Institute of Public Health	UNIPH	0	*	*
1.		Uganda Virus Research Institute	UVRI	0	*	*
48.	Ukraine	Public Health Center *(PHC)* of Ukraine	PHC	0	24	https://www.phc.org.ua/
49.	United Kingdom England	Public Health England	PHE	2	*	*
50.	United states	Centers for Disease Control & Prevention	U.S. CDC	6	*	*
51.	Zambia	Zambia National Public Health Institute	ZNPHI	0	*	*
52.	Tanzania	National Institute for Medical Research	NIMR	1	*	*
Summary statistics				53	277	

*Was not searched among the 8 selected countries
†34 countries with no returns: Afghanistan, Argentina, Bangladesh, Burkina Faso, Cambodia, Cameroon, Côte D'Ivoire, Czech Republic, Denmark, Finland, France, Georgia, Ghana, Guatemala, India, Iran Islamic Republic, Kazakhstan, Kenya, Malawi, Mexico, Mongolia, Morocco, Mozambique, Pakistan, Panama, Russian federation, Saudi Arabia, Sierra Leone, Somalia, Tunisia, Turkey, Uganda, Ukraine, Zambia
‡Articles that describe NPHI activity in more than 1 country are not listed above: 3

Appendix Table 6. Most commonly documented NPHI activities in the COVID-19 response among 18 NPHIs with published documents reflecting their activities

NPHI Function	Roles in the national COVID-19 response
Public health surveillance, problem investigation, and control of risks and threats to public health	- Collecting, analyzing epidemiologic data - Setting case definitions - Screening & testing - Managing laboratory services . Development of guidelines & SOPs . Coordinate the national laboratory network . Producing novel COVID-19 diagnostic technology . Genomic sequencing of the virus . Confirmatory testing . Quality control of diagnostics - Supporting quarantine of positive cases - Contact tracing - Emergency Operations Centers
Public health research	- Creating and maintaining research networks and working groups - Conducting expedited reviews - Conducting or supporting research studies - Bundling data for researchers
Prevention programs and health promotion	- Using websites, social media, and text messaging - Health promotion through multisectoral entities - Working with communities - Establishing hotlines - Health promotion among populations at risk - Supporting vaccination and adverse event reporting
Quality assurance in personal and population-based health services	- Ensuring access to care - Setting up infection prevention and control measures - Ensuring access to Personal Protective Equipment - Producing hospital-based risk assessment tools
Human resources development and training	- Training of laboratorians, contact tracers, vaccination providers, hospital staff - Deploying public health staff to subnational levels - Supporting training platforms and working groups

References

1. de Lusignan S, Lopez Bernal J, Byford R, Amirthalingam G, Ferreira F, Akinyemi O, et al. Influenza and respiratory virus surveillance, vaccine uptake, and effectiveness at a time of cocirculating COVID-19: protocol for the English primary care sentinel system for 2020-2021. JMIR Public Health Surveill. 2021;7:e24341. PubMed https://doi.org/10.2196/24341

2. Del Manso M, Andrianou X, Urdiales AM, Vescio MF, Rota MC, Fabiani M, et al.; Gruppo Referenti regionali della Sorveglianza Integrata COVID-19. La sorveglianza integrata COVID-19 in Italia: output e attività correlate. [COVID-19 integrated surveillance in Italy: outputs and related activities]. Epidemiol Prev. 2020;44(Suppl 2):70–80. PubMed https://doi.org/10.19191/EP20.5-6.S2.105

3. Markus I, Steffen G, Lachmann R, Marquis A, Schneider T, Tomczyk S, et al. COVID-19: cross-border contact tracing in Germany, February to April 2020. Euro Surveill. 2021;26:1–9. PubMed https://doi.org/10.2807/1560-7917.ES.2021.26.10.2001236

4. Petrini C, D'Aprile C, Floridia G, Gainotti S, Riva L, Tamiozzo S. Protection of individual and collective health: ethical-legal issues and opportunities for public health after COVID-19 [cited 2022 May 26.] https://pesquisa.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/pt/covidwho-1139101

5. Espitia-Almeida F, Pereira-Lentino R, Quintero-Soto J, Gómez-Camargo D. Covid-19 in Cartagena and the Bolívar Department, Colombia. Current status, perspectives and challenges until the arrival of the vaccine. Heliyon. 2021;7:e06336. PubMed https://doi.org/10.1016/j.heliyon.2021.e06336

6. Abera A, Belay H, Zewude A, Gidey B, Nega D, Dufera B, et al. Establishment of COVID-19 testing laboratory in resource-limited settings: challenges and prospects reported from Ethiopia. Glob Health Action. 2020;13:1841963. **PMID:** 33200686

7. Fretheim A, Brurberg KG, Forland F. Rapid reviews for rapid decision-making during the coronavirus disease (COVID-19) pandemic, Norway, 2020. Euro Surveill. 2020;25:1. PubMed https://doi.org/10.2807/1560-7917.ES.2020.25.19.2000687

8. Oswaldo Cruz Foundation (Fiocruz). Recomendações para o Método Canguru Durante a Pandemia de COVID-19. Portal of Good Practices in Women's, Children's and Adolescents' Health. March 2020. [cited 2022 May 27]. https://portaldeboaspraticas.iff.fiocruz.br/biblioteca/recomendacoes-para-o-metodo-canguru-durante-a-pandemia-de-covid-19/

9. Hong KH, Lee SW, Kim TS, Huh HJ, Lee J, Kim SY, et al. Guidelines for laboratory diagnosis of coronavirus disease 2019 (COVID-19) in Korea. Ann Lab Med. 2020;40:351–60. PubMed https://doi.org/10.3343/alm.2020.40.5.351

10. Hur JY, Kim KW. Crisis learning and flattening the curve: South Korea's rapid and massive diagnosis of the COVID-19 infection. Am Rev Public Adm. 2020;50:606–13. https://doi.org/10.1177/0275074020941733

11. Issac A, Stephen S, Jacob J, Vr V, Radhakrishnan RV, Krishnan N, et al. The pandemic league of COVID-19: Korea versus the United States, with lessons for the entire world. J Prev Med Public Health. 2020;53:228–32. PubMed https://doi.org/10.3961/jpmph.20.166

12. Jeong GH, Lee HJ, Lee J, Lee JY, Lee KH, Han YJ, et al. Effective control of COVID-19 in South Korea: cross-sectional study of epidemiological data. J Med Internet Res. 2020;22:e22103. PubMed https://doi.org/10.2196/22103

13. Kang YJ. Characteristics of the COVID-19 outbreak in Korea from the mass infection perspective. J Prev Med Public Health. 2020;53:168–70. PubMed https://doi.org/10.3961/jpmph.20.072

14. Kim EY, Kim EK, Lee M, Park HK. COVID-19 Public Health Measures During National Assembly Elections of the Republic of Korea. Osong Public Health Res Perspect. 2020;11:158–63. PubMed https://doi.org/10.24171/j.phrp.2020.11.4.03

15. Kim I, Lee J, Lee J, Shin E, Chu C, Lee SK. KCDC risk assessments on the initial phase of the COVID-19 outbreak in Korea. Osong Public Health Res Perspect. 2020;11:67–73. PubMed https://doi.org/10.24171/j.phrp.2020.11.2.02

16. Lee D, Choi B. Policies and innovations to battle Covid-19—a case study of South Korea. Health Policy Technol. 2020;9:587–97. PubMed https://doi.org/10.1016/j.hlpt.2020.08.010

17. Song R, Choi YS, Ko JY. Operating a national hotline in Korea during the COVID-19 pandemic. Osong Public Health Res Perspect. 2020;11:380–2. PubMed https://doi.org/10.24171/j.phrp.2020.11.6.06

18. Rosa MFF, da Silva EN, Pacheco C, Diógenes MVP, Millett C, Gadelha CAG, et al. Direct from the COVID-19 crisis: research and innovation sparks in Brazil. Health Res Policy Syst. 2021;19:10. PubMed https://doi.org/10.1186/s12961-020-00674-x

19. Song R, Kim HS, Yoo SJ, Lee K, Park JH, Jang JH, et al. COVID-19 in nursing facilities: experience in Republic of Korea. Osong Public Health Res Perspect. 2020;11:164–9. PubMed https://doi.org/10.24171/j.phrp.2020.11.4.04

20. de Souza CTV, de Santana CS, Ferreira P, Nunes JA, Teixeira MLB. da Silveira Gouvêa MIF. Caring in the age of COVID-19: lessons from science and society. Cad Saude Publica. 2020;36. https://doi.org/10.1590/0102-311x00115020

21. Andersson S, Aylott N. Nicholas Aylott. Sweden and coronavirus: unexceptional exceptionalism. Soc Sci. 2020;9:232. https://doi.org/10.3390/socsci9120232

22. Onalu CE, Chukwu NE, Okoye UO. COVID-19 response and social work education in Nigeria: matters arising. Soc Work Educ. 2020;39:1037–47. https://doi.org/10.1080/02615479.2020.1825663

23. Apuke OD, Omar B. How do Nigerian newspapers report COVID-19 pandemic? The implication for awareness and prevention. Health Educ Res. 2020;35:471–80. PubMed https://doi.org/10.1093/her/cyaa031

24. Bledsoe M, Captanian A, Somji A. Special report from the CDC: strengthening social connections to prevent suicide and adverse childhood experiences (ACEs): actions and opportunities during the COVID-19 pandemic. J Safety Res. 2021;77:328–33. PubMed https://doi.org/10.1016/j.jsr.2021.03.014

25. Coronado F, Blough S, Bergeron D, Proia K, Sauber-Schatz E, Beltran M, et al. Implementing mitigation strategies in early care and education settings for prevention of SARS-CoV-2 transmission—eight states, September-October 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1868–72. PubMed https://doi.org/10.15585/mmwr.mm6949e3

26. Ding J, Tuan WJ, Temte JL. Managing close contacts of COVID-19 confirmed cases in metropolitan areas in China. J Public Health Manag Pract. 2020;26:345–8. PubMed https://doi.org/10.1097/PHH.0000000000001189

27. Dirlikov E, Fechter-Leggett E, Thorne SL, Worrell CM, Smith-Grant JC, Chang J, et al.; CDC COVID-19 State, Tribal, Local, and Territorial Response Team. CDC deployments to state, tribal, local, and territorial health departments for COVID-19 emergency public health response—United States, January 21–July 25, 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1398–403. PubMed https://doi.org/10.15585/mmwr.mm6939a3

28. Dollard P, Griffin I, Berro A, Cohen NJ, Singler K, Haber Y, et al.; CDC COVID-19 Port of Entry Team. Risk assessment and management of COVID-19 among travelers arriving at designated U.S. airports, January 17–September 13, 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1681–5. PubMed https://doi.org/10.15585/mmwr.mm6945a4

29. Kesselheim AS, Darrow JJ, Kulldorff M, et al. An overview of vaccine development, approval, and regulation, with implications for COVID-19. Health Aff (Millwood). 2021;40:25-32. https://doi.org/10.1377/hlthaff.2020.01620

30. Miralles O, Sanchez-Rodriguez D, Marco E, Annweiler C, Baztan A, Betancor É, et al. Unmet needs, health policies, and actions during the COVID-19 pandemic: a report from six European countries. Eur Geriatr Med. 2021;12:193–204. PubMed https://doi.org/10.1007/s41999-020-00415-x

31. Omaka-Amari LN, Aleke CO, Obande-Ogbuinya NE, Ngwakwe PC, Nwankwo O, Afoke EN. Coronavirus (COVID-19) pandemic in Nigeria: preventive and control challenges within the first two months of outbreak. Afr J Reprod Health. 2020;24(s1):87–97. PubMed

32. Tagliacozzo S, Albrecht F, Ganapati NE. International perspectives on COVID-19 communication ecologies: public health agencies' online communication in Italy, Sweden, and the United States. Am Behav Sci. 2021;65:934–55. https://doi.org/10.1177/0002764221992832

33. Zhang Y, Shi L, Chen H, Wang X, Sun G. Policy disparities in response to the first wave of COVID-19 between China and Germany. Int J Equity Health. 2021;20:86. PubMed https://doi.org/10.1186/s12939-021-01424-3