

# Global Responses to the COVID-19 Pandemic

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Confronted with a novel coronavirus, countries worldwide were forced to rapidly adjust their public health systems, platforms, and tools to respond to COVID-19. The US Centers for Disease Control and Prevention (CDC) and its global partners adapted health systems and programs originally developed for other purposes, such as controlling the HIV/AIDS pandemic through the US President's Emergency Plan for AIDS Relief (PEPFAR), Global Health Security Agenda implementation, influenza surveillance, and vaccine-preventable disease elimination and eradication. This special supplement of *Emerging Infectious Diseases* highlights responses to the early phases of the COVID-19 pandemic from >80 countries, spanning 6 continents and representing >130 organizations. This article summarizes global adaptations of core public health functions during COVID-19: surveillance, information, and laboratory systems; workforce, institutional, and public health capacity; and clinical and health services delivery.

## Surveillance, Information, and Laboratory Systems

CDC has provided longstanding support to strengthen surveillance, health information, and laboratory systems globally. Examples of such platforms used during the COVID-19 pandemic include the early warning and response surveillance system (1); respiratory (2), influenza (3), and acute febrile illness surveillance systems (4); global health security-supported information systems (e.g., District Health Information Software, version 2 [DHIS2]) (5); and PEPFAR-supported HIV and tuberculosis (TB) information systems (6,7). Respiratory disease surveillance guidance was developed for COVID-19 in 9 temporary camps for displaced persons along the Thailand-Myanmar border, showing that such systems can be effective during pandemics (2). Countries' ministries of health (MOH), the World Health Organization

(WHO), CDC, academic institutions, and nongovernmental organizations adapted international influenza surveillance systems for SARS-CoV-2 infections (3). CDC collaborated with MOH and partners to leverage existing acute febrile illness surveillance systems in 5 countries to collect and generate COVID-19 data needed for action (4). Kinkade et al. described 3 countries' experience strengthening surveillance systems and reporting using DHIS2 for COVID-19 (5). Mirza et al. showed how health information systems for HIV and TB were modified for COVID-19 (6). PEPFAR-supported HIV and TB information management systems and diagnostic networks were adapted for SARS-CoV-2 testing in 16 low- to middle-income countries during the pandemic (7). Surveys provided key data on SARS-CoV-2 cases in Pakistan (8) and Malawi (9). Ohlsen et al. found international disparities in SARS-CoV-2 sequencing capacity and timeliness while viral genomic surveillance coverage increased globally (10). Smith-Sreen et al. compared 3 waves of the pandemic in 10 countries in southern Africa (11). Three neighboring countries in Africa used toolkits to analyze population movements and prioritize surveillance, cross-border collaboration, and communication strategies (12). Kenu et al. explained how geographic information systems were used for contact tracing to identify COVID-19 cases in Ghana (13). Chiou et al. developed a COVID-19 infodemic surveillance system to produce actionable insights to help address misinformation (14).

## Workforce, Institutional, and Public Health Capacity Development

CDC-supported Field Epidemiology Training Programs (FETPs) (15,16), Public Health Emergency Management (PHEM) Fellowships (17), and national public health institutes (NPHIs) (18) have contributed to leadership, disease detection and surveillance, and response and workforce capacity during the pandemic. Bell et al. described contributions to COVID-19 preparedness and response from 32 FETPs with 2,300 trainees and ≈7,400 graduates, representing >80 coun-

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tries and 3 regions (15). Since 2013, CDC has offered the PHEM Fellowship to develop an international emergency response workforce; an assessment examined PHEM graduates' roles during the pandemic (17). Zuber et al. reviewed the pivotal role NPHIs have played in pandemic response and identify gaps and priorities for further research (18).

Longstanding partnerships with MOH and other governmental bodies helped strengthen COVID-19 response capacity in Kenya (19), Nigeria (20), South Africa (21), and Cameroon (22). In Kenya, COVID-19 helped advance establishment of NPHIs and national and county-level emergency operations centers, workforce development and deployment, and training in surveillance, laboratory diagnostics, and infection prevention and control (IPC) (19). The Nigeria Presidential Task Force on COVID-19 worked with partners to develop a comprehensive National Pandemic Response Plan (20). In Cameroon, CDC's global health programs were leveraged to respond to COVID-19, helping ensure continued delivery of HIV services and other health programs (22). Through PEPFAR, CDC used HIV Project Extension for Community Healthcare Outcomes programs, a model for virtual clinical mentorship, to address and assess healthcare workers' response to COVID-19 (23). In 2021, the Public Health Center of Ukraine, Ukraine's NPHI, engaged with faith communities to address public health measures during religious gatherings (24).

### Clinical and Health Services Delivery and Impact

The pandemic also affected clinical and health services delivery. This supplement describes impacts on vaccine-preventable disease surveillance (25), expansion of COVID-19 vaccinations (26), and the effects of decreased hepatitis B immunization coverage (27). In the WHO Africa region, more than 200 Stop Transmission of Polio (STOP) Program consultants were surveyed to clarify how vaccine-preventable disease surveillance systems were disrupted during the pandemic (25). CDC's COVID-19 International Vaccine Implementation and Evaluation program applied lessons learned from Ebola, influenza, and meningococcal serogroup A conjugate vaccine introductions for the delivery of COVID-19 vaccines (26). Experiences from past rubella vaccination programs (28), yellow fever and polio immunization campaigns for COVID-19 vaccine deployment and safety monitoring in Ghana (29), and the effectiveness of inactivated whole-virus COVID-19 vaccine among healthcare personnel in Peru (30) can also inform future responses. Zambia integrated COVID-19 vaccination at HIV treatment centers and combined activities planned for 2021 World AIDS Day

to help increase vaccination outreach (31). Kimani et al. assessed IPC strategies and health facility readiness for responding to COVID-19 in Kenya, providing important data to guide IPC improvements (32). Gomes et al. described initiatives to strengthen IPC in healthcare facilities in 4 countries for the prevention of healthcare-associated transmission of SARS-CoV-2 (33).

COVID-19 affected other clinical services, including male circumcision for HIV prevention in sub-Saharan Africa (34) and care offered to survivors of sexual violence in Kenya (35). COVID-19 also caused clinical and socioeconomic impacts on agricultural workers in Guatemala (36). Protocols on community-based management of acute malnutrition in Uganda, Ethiopia, and Somalia needed modification to continue essential feeding services during the pandemic (37).

### Conclusion

International responses to COVID-19 demonstrated diverse adaptations, effects, and some improvements to public health systems and institutions; long-term global partnerships and collaborations across technical domains were central. The articles in this supplement issue contribute to ongoing efforts to stop outbreaks at their source and advance health equity to make the world safer, healthier, and more prepared for future public health emergencies.

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## References

1. Ricks PM, Njie GJ, Dawood FS, Blain AE, Winstead A, Popoola A, et al. Lessons learned from CDC’s global COVID-19 Early Warning and Response Surveillance system. *Emerg Infect Dis.* 2022;28(Suppl):S8–S16. <https://doi.org/10.3201/eid2813.212544>
2. Knust B, Wongjindanon N, Moe AA, Herath L, W. Kaloy, Soe TT, et al. Enhancing respiratory disease surveillance to detect COVID-19 in shelters for displaced persons Thailand–Myanmar border, 2020–2021. *Emerg Infect Dis.* 2022;28(Suppl):S17–S25. <https://doi.org/10.3201/eid2813.220324>
3. Marcenac P, McCarron M, Davis W, Igboh LS, Mott JA, Lafond KE, et al. Leveraging international influenza surveillance systems and programs during the COVID-19 pandemic. *Emerg Infect Dis.* 2022;28(Suppl):S26–S33. <https://doi.org/10.3201/eid2813.212248>
4. Shih DC, Silver R, Henao OL, Alemu A, Audi A, Bigogo G, et al. Incorporating COVID-19 into acute febrile illness surveillance systems, Belize, Kenya, Ethiopia, Peru, and Liberia, 2020–2021. *Emerg Infect Dis.* 2022;28(Suppl):S34–S41. <https://doi.org/10.3201/eid2813.220898>
5. Kinkade C, Russpatrick S, Potter R, Saebø J, Sloan M, Odongo G, et al. Extending and strengthening routine DHIS2 surveillance systems for COVID-19 responses in Sierra Leone, Sri Lanka, and Uganda. *Emerg Infect Dis.* 2022;28(Suppl):S42–S48. <https://doi.org/10.3201/eid2813.220711>
6. Mirza M, Grant-Greene Y, Valles MPJS, Justice P, Juin S, Brice S, et al. Leveraging PEPFAR-supported health information systems for COVID-19 pandemic response. *Emerg Infect Dis.* 2022;28(Suppl):S49–S58. <https://doi.org/10.3201/eid2813.220751>
7. Rottinghaus Romano E, Sleeman K, Hall-Eidson P, Zeh C, Bhairavabhotla R, Zhang G, et al. Contribution of PEPFAR-supported HIV and TB molecular diagnostic networks to COVID-19 testing preparedness in 16 countries. *Emerg Infect Dis.* 2022;28(Suppl):S59–S68. <https://doi.org/10.3201/eid2813.220789>
8. Aheron S, Victory KR, Imtiaz A, Fellows I, Gilani SI, Gilani B, et al. A nationally representative survey of COVID-19 in Pakistan, 2021–2022. *Emerg Infect Dis.* 2022;28(Suppl):S69–S75. <https://doi.org/10.3201/eid2813.220728>
9. Theu JA, Kabaghe AN, Bello G, Chitsa-Banda E, Kagoli M, Auld A, et al. SARS-CoV-2 prevalence in Malawi based on data from surveys of communities and health workers in 5 high-burden districts, October 2020. *Emerg Infect Dis.* 2022; 28(Suppl):S76–S84. <https://doi.org/10.3201/eid2813.212348>
10. Ohlsen EC, Hawksworth AW, Wong K, Guagliardo SAJ, Fuller JA, Sloan ML, et al. Determining gaps in publicly shared SARS-CoV-2 genomic surveillance data by analysis of global submissions. *Emerg Infect Dis.* 2022;28(Suppl):S85–S92. <https://doi.org/10.3201/eid2813.220780>
11. Smith-Sreen J, Miller B, Kabaghe AN, Kim E, Wadonda-Kabondo N, Frawley A, et al. Comparison of COVID-19 pandemic waves in 10 countries in southern Africa, 2020–2021. *Emerg Infect Dis.* 2022;28(Suppl):S93–S104. <https://doi.org/10.3201/eid2813.220228>
12. Merrill RD, Kilamile F, White M, Eurien D, Mehta K, Ojwang J, et al. Using population mobility patterns to adapt COVID-19 response strategies in 3 East Africa countries. *Emerg Infect Dis.* 2022;28(Suppl):S105–S113. <https://doi.org/10.3201/eid2813.220848>
13. Kenu E, Barradas DT, Bando DA, Frimpong JA, Noora CL, Bekoe FA. Community-based surveillance and geographic information system-linked contact tracing in COVID-19 case

- identification, Ghana, March–June 2020. *Emerg Infect Dis.* 2022;28(Suppl):S114–S120. <https://doi.org/10.3201/eid2813.221068>
14. Chiou H, Voegeli C, Wilhelm E, Kolis J, Brookmeyer K, Prybyl-ski D. The future of infodemic surveillance as public health surveillance. *Emerg Infect Dis.* 2022;28(Suppl):S121–S128. <https://doi.org/10.3201/eid2813.220696>
  15. Bell E, Mittendorf C, Meyer E, Barnum O, Reddy C, Williams S, et al. Continuing contributions of Field Epidemiology Training Programs to global COVID-19 response. *Emerg Infect Dis.* 2022;28(Suppl):S129–S137. <https://doi.org/10.3201/eid2813.220990>
  16. Singh SK, Dikid T, Dhuria M, Bahl A, Chandra R, Vaisakh TP, et al. India Field Epidemiology Training Program response to COVID-19 pandemic, 2020–2021. *Emerg Infect Dis.* 2022;28(Suppl):S138–S144. <https://doi.org/10.3201/eid2813.220563>
  17. Krishnan S, Espinosa C, Podgornik MN, Haile S, Aponte JJ, Brown CK, et al. COVID-19 response roles among CDC international Public Health Emergency Management Fellowship graduates. *Emerg Infect Dis.* 2022;28(Suppl):S145–S150. <https://doi.org/10.3201/eid2813.220713>
  18. Zuber A, Sebeh Y, Jarvis D, Bratton S. Exploratory literature review of the role of national public health institutes in COVID-19 response. *Emerg Infect Dis.* 2022;28(Suppl):S151–S158. <https://doi.org/10.3201/eid2813.220760>
  19. Herman-Roloff A, Aman R, Samandari T, Kasera K, Emukule GO, Amoth P, et al. Adapting longstanding public health collaborations between government of Kenya and CDC Kenya in response to the COVID-19 pandemic, 2020–2021. *Emerg Infect Dis.* 2022;28(Suppl):S159–S167. <https://doi.org/10.3201/eid2813.221550>
  20. Bolu O, Mustapha B, Ihekweazu C, Muhammad M, Hassan A, Abdulwahab A, et al. Effect of Nigeria Presidential Task Force on COVID-19 pandemic, Nigeria. *Emerg Infect Dis.* 2022;28(Suppl):S168–S176. <https://doi.org/10.3201/eid2813.220254>
  21. Taback-Esra R, Morof D, Briggs-Hagen M, Savva H, Mthethwa S, Williams D, et al. Use of epidemiology surge support to enhance robustness and expand capacity of SARS-CoV-2 pandemic response, South Africa. *Emerg Infect Dis.* 2022;28(Suppl):S177–S180. <https://doi.org/10.3201/eid2813.212522>
  22. Dokubo EK, Shang JD, N'Dir A, Ndongmo CB, Okpu G, Fadil YM, et al. Building on capacity established through US Centers for Disease Control and Prevention global health programs to respond to COVID-19, Cameroon. *Emerg Infect Dis.* 2022;28(Suppl):S181–S190. <https://doi.org/10.3201/eid2813.221193>
  23. Wright J, Tison L, Chun H, Gutierrez C, Ning MF, Morales RE, et al. Use of Project ECHO in response to COVID-19 in countries supported by US President's Emergency Plan for AIDS Relief. *Emerg Infect Dis.* 2022;28(Suppl):S191–S196. <https://doi.org/10.3201/eid2813.220165>
  24. Erickson-Mamane L, Kryshchuk A, Gvozdetska O, Rossovskiy D, Glatt A, Katz D, et al. Faith community engagement to mitigate COVID-19 transmission associated with mass gathering, Uman, Ukraine, September 2021. *Emerg Infect Dis.* 2022;28(Suppl):S197–S202. <https://doi.org/10.3201/eid2813.220183>
  25. Bigouette JP, Callaghan AW, Donadel M, Porter AM, Rosencrans L, Lickness JS, et al. Effects of COVID-19 on vaccine-preventable disease surveillance systems in the World Health Organization African Region, 2020. *Emerg Infect Dis.* 2022;28(Suppl):S203–S207. <https://doi.org/10.3201/eid2813.220088>
  26. Soeters HM, Doshi RH, Fleming M, Adegoke OJ, Ajene U, Aksnes BN, et al. CDC's COVID-19 International Vaccine Implementation and Evaluation program and lessons from earlier vaccine introductions. *Emerg Infect Dis.* 2022;28(Suppl):S208–S216. <https://doi.org/10.3201/eid2813.212123>
  27. Kabore HJ, Li X, Allison RD, Avagyan T, Mihigo R, Takashima Y, et al. Effects of decreased immunization coverage for hepatitis B virus caused by COVID-19 in World Health Organization Western Pacific and African Regions, 2020. *Emerg Infect Dis.* 2022;28(Suppl):S217–S224. <https://doi.org/10.3201/eid2813.212300>
  28. Dixon MG, Reef SE, Zimmerman LA, Grant GB. Past as prologue – use of rubella vaccination program lessons to inform COVID-19 vaccination. *Emerg Infect Dis.* 2022;28(Suppl):S225–S231. <https://doi.org/10.3201/eid2813.220604>
  29. Amponsa-Achiano K, Frimpong JA, Barradas D, Bandoh DA, Kenu E. Leveraging lessons learned from yellow fever and polio immunization campaigns during COVID-19 pandemic, Ghana, 2021. *Emerg Infect Dis.* 2022;28(Suppl):S232–S237. <https://doi.org/10.3201/eid2813.221044>
  30. Arriola CS, Soto G, Westercamp M, Bollinger S, Espinoza A, Grogl M, et al. Effectiveness of whole-virus COVID-19 vaccine among healthcare personnel Lima, Peru. *Emerg Infect Dis.* 2022;28(Suppl):S238–S243. <https://doi.org/10.3201/eid2813.212477>
  31. Bobo P, Hines JZ, Chilengi R, Auld AF, Agolory SG, Silumesii A, et al. Leveraging HIV program and civil society to accelerate COVID-19 vaccine uptake, Zambia. *Emerg Infect Dis.* 2022;28(Suppl):S244–S246. <https://doi.org/10.3201/eid2813.220743>
  32. Kimani D, Ndegwa L, Njeru M, Wesangula E, Mboya F, Macharia C, et al. Adopting World Health Organization multimodal infection prevention and control strategies to respond to COVID-19, Kenya. *Emerg Infect Dis.* 2022;28(Suppl):S247–S254. <https://doi.org/10.3201/eid2813.212617>
  33. Gomes DJ, Hazim C, Safstrom J, Herzig C, Luvsansharav U, Dennison C, et al. Infection prevention control initiatives to prevent healthcare-associated transmission of SARS-CoV-2, East Africa. *Emerg Infect Dis.* 2022;28(Suppl):S255–S261. <https://doi.org/10.3201/eid2813.212352>
  34. Peck ME, Ong KS, Lucas T, Prainito A, Thomas AG, Brun A, et al. Effects of COVID-19 pandemic on voluntary medical male circumcision services for HIV prevention, sub-Saharan Africa, 2020. *Emerg Infect Dis.* 2022;28(Suppl):S262–S269. <https://doi.org/10.3201/eid2813.212455>
  35. Ochieng W, Sage EO, Achia T, Oluoch P, Kambona C, Njenga J, et al. : Sexual Violence Trends before and after Rollout of COVID-19 Mitigation Measures, Kenya. *Emerg Infect Dis.* 2022;28(Suppl):S270–S276. <https://doi.org/10.3201/eid2813.220394>
  36. Olson D, Calvimontes DM, Lamb MM, Guzman G, Barrios E, Chacon A, et al. Clinical and economic impact of COVID-19 on agricultural workers, Guatemala. *Emerg Infect Dis.* 2022;28(Suppl):S277–S287. <https://doi.org/10.3201/eid2813.212303>
  37. Shragai T, Talley L, Summers A, Behringer H, Wrabel M, Stobaugh H, et al. Outcomes after acute malnutrition program adaptations to COVID-19, Uganda, Ethiopia, and Somalia. *Emerg Infect Dis.* 2022;28(Suppl):S288–S298. <https://doi.org/10.3201/eid2813.212266>

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