Digital Applications and Tools Across an Epidemiological Curve

A framework for governments, investors, implementing organizations, and the digital health community at large to use to strategically plan adaptation, use, and scale of digital tools during different phases of pandemics and outbreaks

digital square

Appropriately integrating digital technologies into epidemic and/or pandemic responses can drive efficiencies in the health system and enable more rapid data exchange of information to inform evidence-based responses. Adaptations of existing tools tailored to different phases of a response can be the most strategic use of digital interventions, as long as they are coupled with a systematic approach to adapt, use, and scale data from deployments.

Digital Square designed Version 1 of the Digital Applications and Tools Across an Epidemiological Curve (DATEC) as a strategic framework for governments, investors, implementing organizations, and the digital health community at large to better understand how existing digital tools can be adapted and used during different phases of an outbreak. This framework is meant to highlight how digital technologies, which should already be present in a country, can most strategically be leveraged to augment response during an epidemic and/or pandemic.

Funded by United States Agency for International Development (USAID), Digital Square developed this framework in the context of the COVID-19 pandemic in partnership with USAID, the Centers for Disease Control and Prevention (CDC), the Bill & Melinda Gates Foundation, the German Corporation for International Cooperation (GIZ), the World Bank, and other investors.

The basis for the framework, shown on page 2, visualizes the DATEC and depicts how 13 use cases intersect at different points of a pandemic. Digital Square identified, aligned, and prioritized these use cases with USAID and GIZ as ones that deserve heavy emphasis during a pandemic. The DATEC has an accompanying table that includes descriptions of why a use case is highlighted in the DATEC during each phase, and how countries should plan to adapt and use digital health tools to address these use cases at points in time across the pandemic.

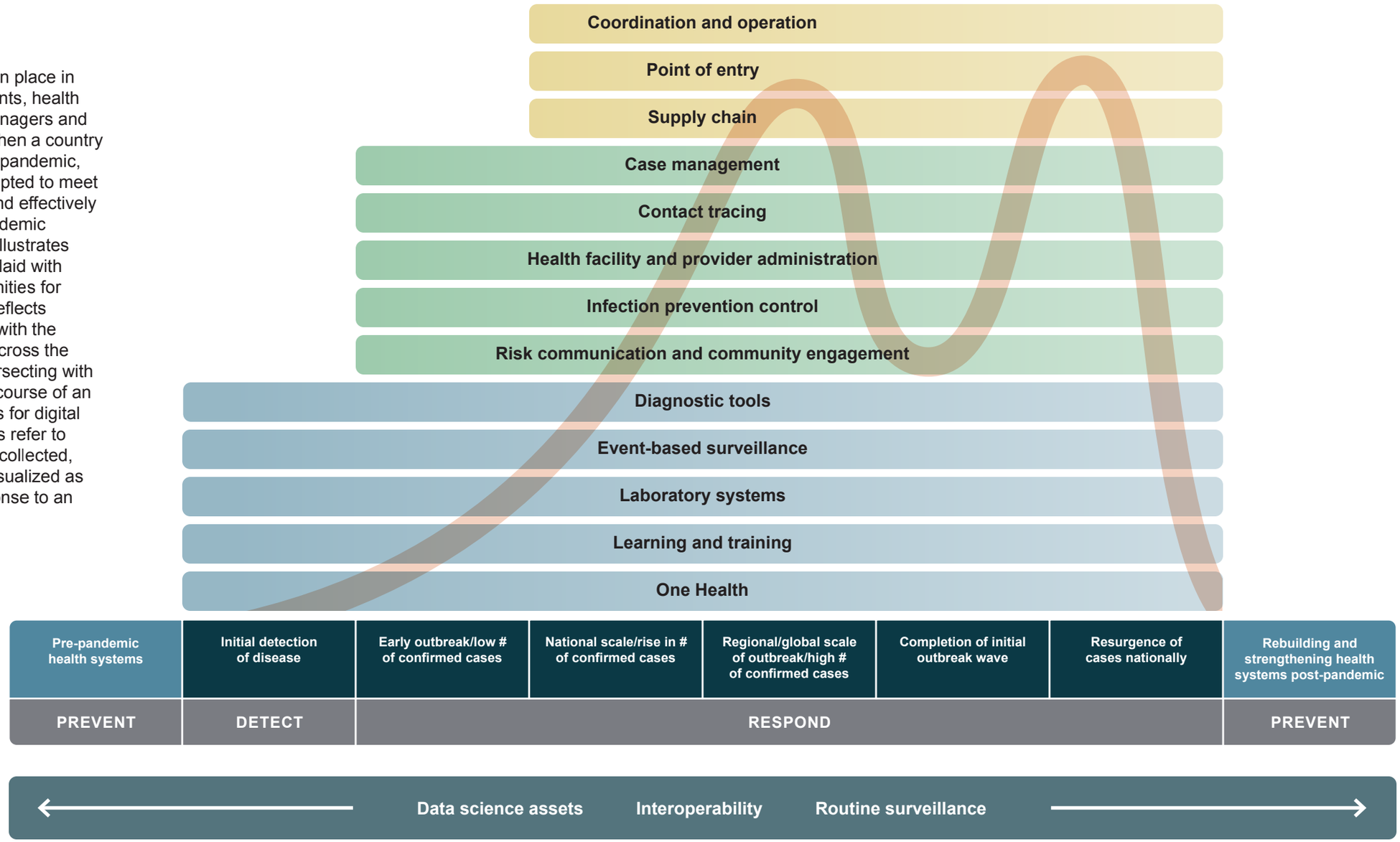
To further examine how to use the DATEC, this resource includes a deep dive into the utilization of outbreak tools, the need for strong data and digital health foundations within a health system, and a matrix to facilitate investor coordination in digital tools.

Governments, investors, implementing organizations, and the digital health community at large can use this framework as a guide to enable identification and adaptation of tools for quick deployment during an epidemic and/or pandemic. This framework can also be used outside of a pandemic to aid in planning implementation of digital tools where there are gaps in use cases.

Contents

Use cases across DATEC

Digital tools should already be in place in countries, aiding support to clients, health workers, and health system managers and strengthening data services. When a country is facing a disease outbreak or pandemic, existing digital tools can be adapted to meet emerging needs to efficiently and effectively support the response to the epidemic and/or pandemic. The DATEC illustrates the phases of an outbreak overlaid with use cases, or possible opportunities for interventions. The curve itself reflects the prevalence of the disease, with the chronological phases labeled across the bottom. Use cases, shown intersecting with the curve, vary throughout the course of an outbreak and offer opportunities for digital tools to be deployed. Use cases refer to the specific type of information collected, stored, tracked, analyzed, or visualized as it relates to the functional response to an epidemiological event.



Use case explanations

The table below includes information about the 13 use cases visualized in the DATEC graphic in the order in which they are introduced from top to bottom. The use cases are grouped by the color gradient that mirrors at which phase of the pandemic they enter the DATEC. **Text in blue** indicates the most strategic opportunities to adapt digital tools recommended at different phases of a pandemic.

Use case	Objective	Functional description	Initial detection of disease	Early outbreak/low # of confirmed cases	National scale/rise in # of confirmed cases	Regional/global scale of outbreak/high # of confirmed cases	Completion of initial outbreak wave	Resurgence of cases nationally
Coordination and operation	Streamline data collection and analysis to inform response efforts.	Support emergency operation centers and other coordination response efforts that make decisions about disease outbreaks.			When large numbers of cases are confirmed in a country, emergency operation centers (EOCs) should leverage robust data analytics and visualization tools to better understand where cases are concentrated and impacts of treatments in communities, and to predict where a surge in cases may come next. National coordination teams and government should rapidly use this information to inform action including where to reinforce testing, types of messaging to share with communities, and what support is needed for frontline health workers including supplies like protective equipment and staff shortage mitigation efforts.	**Emergency operation centers (EOCs) can use digital technologies such as robust data science and analytics tools to better understand impact on a country where cases are most concentrated at border regions. Countries should share their insights with regional and international coordination units, and identify gaps in data where more information in a country is needed.**	Digital tools for coordination and operation should continue to be used to better understand impacts on communities, health workers, and health sites, even as case numbers decline. Modeling and forecasting tools can help countries plan next steps for addressing the outbreak and prioritize measures to continue reduction in the number of cases.	Emergency operation centers (EOCs) and national task forces for diseases should continue adapting their approaches to data use, gaining insights from interoperable tools. At this point in the epidemiological curve, many countries will be planning deployment of a vaccine or new treatment protocols. Leveraging data from multiple tools will strengthen data quality and use and better equip governments to address a resurgence in cases as well as measures to end the outbreak.
Point of entry	Detect and manage international spread of disease by identifying suspected infected persons at border entry points.	System to strengthen border health security, screen, and follow up with suspected infected persons at ports of entry and other border entry points.			**To help prevent the import of new cases of a disease, digital point-of-entry screening tools can be used at borders, prioritizing airports, trucking routes, and shipping ports of entry. Using digital tools to capture traveler screening should also be used in coordination with contact-tracing tools if there is a suspected case.**	**As cases rise outside of national borders, using digital tools to track people entering the country, especially where they are entering from, is important to track potential cases as well as use information for mitigation efforts. Travelers may not be allowed to enter a country if they do not pass screening measures, and capturing this data to share with other countries is another mitigation effort to limit spread of the disease.**	Improving point-of-entry screening as new side effects are identified can ensure appropriate tracking and screening of travelers in a country. Updating the digital forms and ensuring screening officers are aware of changes will maintain the integrity of the tools. Point-of-entry tools should also be made interoperable with surveillance, lab, contact tracing, and other systems for seamless data exchange.	Data from screening tools can be assessed and used to inform national decisions that may restrict travel from certain countries or regions. Data can also reveal where suspected cases are confirmed, and from which areas outside of the country. Artificial intelligence (AI)/machine learning (ML) can look for patterns where point-of-entry tools have robust information.
Supply chain	Support allocation of resources to aid in response.	System for monitoring facility readiness and stock levels.			**While supply chain and logistics management systems are always used to manage health commodities, these systems enter the DATEC at this point because a rise in cases signals an extra push on the supply chain to ensure that testing kits, therapeutics, and other treatment commodities, as well as essential supplies like gloves, cleaning agents, etc., are ordered, tracked, and delivered on time at health facilities. Robust supply chain systems are needed to correctly identify and collect samples that may need to be analyzed at national reference laboratories.**	**As cases rise, demand for supplies will likely limit availability. Logistics management information systems can help ensure accuracy of ordering and timeliness of shipments, and should there be a delay, provide visibility into data insights around the supply chain. Governments should ensure use of forecasting tools and built-in data visualizations and analytics at this point of an outbreak, and report any delays in supply through supply chain systems.**	Not all health sites have access to robust logistics management and other supply chain systems. Governments should assess and evaluate gaps in the health system and where to prioritize introduction of supply chain systems, including cold chain monitoring and other systems that are essential during an outbreak.	Reliable access to vaccines, essential medicines for treatment, testing supplies, and other commodities can help accelerate management of the disease and curb further spread. Digital tools can ensure robust data systems to track inventory, shelf life, and stock as well as manage the transactional movements of vaccines within multi-level supply chains. Robust analytics, artificial intelligence (AI)/machine learning (ML), and other data science tools can support countries to ensure their supply chains are working effectively.
Case management	Systematic processing of suspected infected persons.	System for documenting client details and clinical interactions.		When new cases arise, digitals tools supporting case management are critically important for managing clients who are suspected and/or confirmed positive for the disease, processing patients, monitoring clinical interactions across facilities, and using this information to limit spread of the disease.	**As cases rise, case management tools ensure coordination of patients throughout a country, allowing health providers to appropriately document health visits, follow-up needs, and treatment protocols. With high numbers of cases, digital tools improve efficiency in management of cases and can even coordinate referrals for high-risk cases.**	**During this outbreak phase, using digital case management tools will be essential to track the high number of cases, including those that span national borders. Case management tools must be robust and ideally able to exchange data or export case data with health information systems in other countries.**	**As cases begin to decline, case management tools will help track health visits related to the outbreak, but can also track side effects, comorbidities, mental health side effects, and other impacts the disease has on patients. Case management tools can be expanded to track information about treatment needs that are linked to and extend beyond the disease itself.**	As cases rise, comorbidities and side effects become more apparent. Case management tools are a priority for countries in advanced stages of an outbreak. By this time, countries should be deploying tools that continue to flex to meet patient and provider needs, as well as tools that give decision-makers information to appropriately respond to the outbreak, taking measures to curb further outbreaks.

Use case	Objective	Functional description	Initial detection of disease	Early outbreak/low # of confirmed cases	National scale/rise in # of confirmed cases	Regional/global scale of outbreak/high # of confirmed cases	Completion of initial outbreak wave	Resurgence of cases nationally
Contact tracing	Tracking individuals to manage and reduce spread of disease.	Identification and follow-up with people who have had high-risk interactions with infected persons.		**As cases rise in a country, it is essential to deploy contact tracing tools to track the patient and anyone who has been exposed to the disease by that patient. Digital contact tracing tools deployed at this stage enable authorities to track and slow the spread of the disease by imposing isolation measures on infected and exposed patients and to understand geographically where clusters of exposed patients are located. Contact tracing tools also send alerts to exposed clients.**	**As with case management tools, as cases rise, contact tracing technologies support coordination with clients in the health system. In addition to tracking patients, these tools streamline the electronic capture and management of data on patients and contacts by enabling automation of contact notification and follow-up, and by allowing patients and contacts to electronically self-report medical information and services along with contacts.**	Contact tracing tools should ideally be developed to exchange data with other systems including those outside of a national health system. As cases rise across country borders, deploying tools to track exposures is essential to curb further outbreaks of the disease.	Contact tracing tools should continue to be used even as case numbers decline. It may be that a country lacks capacity to appropriately deploy contact tracing tools with extremely high numbers of cases. This is a time to reassess processes and workflows and to deploy best practices for contact tracing.	As cases rise, often higher than during initial outbreak waves, contact tracing tools are a priority for countries to gather information, communicate with patients, and use digital technologies to aid enforcement of measures to reduce spread of the disease.
Health facility and provider administration	Robust organizational underpinning for response.	System for managing facility accounting and human resources.		Health providers play an important role in providing care to suspected and confirmed patients. Ensuring these tools are adapted to meet the surge of health provider needs such as tracking increased skill sets, overtime payments, and redistribution of health workforce should be considered throughout the outbreak. Prioritizing health care workers early in an outbreak signals support and can improve their physical and mental well-being.	As cases rise across the country, the health workforce may need to be redistributed and task shifting may need to be explored for response efforts or to maintain essential health services. Digital tools can aid in providing information and tracking health workers, including community health workers.	**The availability of health workers will likely be disrupted due to sickness and excessive demands as an outbreak expands globally. Health facility and administration tools can track gaps in services and staff, relaying important information to the district, regional, and national level.**	**Health worker motivation and satisfaction is important to health workforce strengthening, especially as constraints during an outbreak are likely to significantly impact health worker physical and mental health. These tools can aid in supporting health workforce retention and planning as well as ensuring health workers are paid and incentivized appropriately.**	As cases surge again in a country, these tools should remain a priority to support ongoing administrative processes for the health workforce.
Infection prevention control	Prevent infection among clients and health workers.	Systems that support triage; isolation; water, sanitation, and hygiene; and waste management to prevent transmission to staff, other clients, and the community.		Digital tools such as SMS, mobile apps, and remote monitoring tools can aid in infection prevention control (IPC) at all levels of the health system. Contact tracing and case management tools are also specific tools that can be used for infection prevention control. Behavior change communication tools can support linfection prevention efforts.	**As cases rise, the use of digital tools to curb infection becomes much more important. Geographic information system (GIS) technologies can be harnessed for mapping locations of clusters in a country to guide emergency response efforts.**	Digital tools can be harnessed for mapping locations of outbreaks in countries including border regions, supporting cross-border data sharing and analysis to inform response.	Digital tools and data can pinpoint remaining outbreak locations and help direct approaches to reduce pockets of the virus, including by protecting health workers.	Digital tools and data should continue to inform approaches including protection for health workers.
Risk communication and community engagement	Improve public awareness of facts and best practices for disease prevention.	System for channeling messaging and communication to the public to promote public awareness, counter misinformation, encourage treatment-seeking behaviors, and encourage citizens to take appropriate actions to promote health.		As countries identify disease outbreaks, SMS and other digital tools can be used to share information with the community about a potential outbreak of a new disease or renewed outbreak of a disease already well known to a community. Client interaction messaging systems should alert the public about where outbreaks are concentrated, remind citizens of safe public health measures for protection against an outbreak, and explain what to do if they experience symptoms. Early messaging can raise awareness and promote safe environments to curb disease spread.	**As cases rise, digital tools should be used to connect with clients, especially in rural communities, to provide essential information for public health safety. Tools can be used to dispel rumors and share information about side effects, how to seek testing if a person has a suspected case, and what treatment options are available. Countries should leverage existing systems in place to connect with clients and communities for efficient, trustworthy information dissemination.**	Regional and global outbreaks can cause panic and chaos. Using SMS, hotlines, and other digital communication tools can ensure communities have the information they need to protect themselves. Engagement from subnational and national governments is important to build trust in the health system and, when used properly, digital tools can bridge essential communications, especially important in rural areas where access to information can be limited.	During an outbreak, as treatment options may vary and protocols change while more is learned about a disease, digital tools can be used to share the latest evidence with communities. Countries should evaluate community needs and leverage digital tools appropriately to connect with communities, including through exploring the use of pictures, audio recordings, video, and text.	
Diagnostic tools	Improve efficiency in clinical diagnosis and collection of data from diagnostic tools.	Diagnostic tools with digital connectivity to support monitoring, documentation, and reporting of diagnoses.	**Digitals tools are used to support diagnostics through the entire DATEC and are responsible for monitoring, documenting, and reporting diagnoses. As cases are detected, countries should prioritize supply of diagnostics and ensure health care providers are informed on how to use them and capture data of diagnostic results.**	Digital tools can be used to improve data quality, contributing to analyses and ensuring accurate diagnosis.	**As cases rise, rapid diagnostic tools may need to be introduced at health facilities and pharmacies and at the community level to diagnose suspected cases. Data from these rapid results should be updated in case management, health management information system (HMIS), lab, and other health information systems.**	When cases reach the global scale, it is likely that new diagnostic tools will enter the market. Countries should ensure proper supply of approved diagnostics and ensure standards are met before deployment.	Diagnostic tools should continue to be used, and even enhanced, as cases reduce in a country. At this time, countries can assess which tools were most available to health workers, were easiest to use, produced the fastest and most accurate results, and made it easy to share data with digital information systems such as surveillance and case management systems.	The most effective diagnostic tools should be used as cases rise. At this point, interoperability of diagnostics with country health information systems is important.

Use case	Objective	Functional description	Initial detection of disease	Early outbreak/low # of confirmed cases	National scale/rise in # of confirmed cases	Regional/global scale of outbreak/high # of confirmed cases	Completion of initial outbreak wave	Resurgence of cases nationally
Event-based surveillance	Early detection of outbreaks and epidemics, case detection and investigation, and national and subnational emergency operations to ensure rapid management of infectious disease.	System with functionality or ability to monitor patterns indicative of infectious disease epidemic outbreak; systems to detect and document cases of emerging disease threats, investigate those threats, identify cases, and manage the response.	**Routine surveillance and event-based public health surveillance systems look at reports, stories, rumors, and other information about health events that could be a serious risk to public health. These digital tools should capture information in a complete and timely manner. For new viruses, tools deploying these use cases often provide the first digital touchpoints signaling a disease outbreak.**	**As cases rise, countries should prioritize timeliness and completeness of their surveillance tools. Many of the surveillance tools are likely aggregate trackers that are not too complex and are easy to implement. District and regional data managers should enforce use of these tools from facilities as cases are confirmed in a country.**	As cases rise in a country, more complex event-based surveillance tools should be used, such as tools that can capture patient-level data versus those that capture aggregate data. These tools can enroll a case and track it over time through laboratory confirmation and case outcome, often working as case management tools. Note there is a heavy burden of data entry as cases begin to rapidly rise.	As cases expand globally, surveillance tools aid not only in reporting and case management at the country level but also provide information globally, informing where resources and needs are greatest across a region. Tools can also highlight areas at border regions where cases are surging, informing other countries about their own response efforts.	Event-based surveillance should continue to be used even as cases decline. This is a time to assess timeliness and completeness of data as well as to perform data quality checks to ensure processes are streamlined should a resurgence of the disease emerge.	During a resurgence, surveillance tools can continue to aid in reporting and case management at the country level and internationally. Multiple dimensions of analyses and revised workflows can signal how a country may institute measures to curb the outbreak.
Laboratory systems	Validation of infectious disease incidence.	System with functionality to order lab tests, follow progress of client samples, and receive test results (e.g., confirm suspected cases).	**Laboratory information systems have the capacity to improve clinical decision-making and quality of care at site level. These systems should be in place in concert with national accredited laboratories to aid in testing and tracking information of client samples.**	**Agile lab systems should be adapted to capture details about emergent diseases. When used consistently, these systems can also alleviate the administrative burden on laboratory personnel and improve turnaround time of testing and sharing results with health providers and clients.**	Information from laboratory information systems can be leveraged to make data-driven, population-level public health decisions. As cases rise in a country, high-quality laboratory data can be used as a salient point in concert with data from surveillance and other systems to inform decisions to curb the disease.	Information from laboratory information systems can be leveraged to make data-driven, population-level public health decisions. As cases rise across borders reaching a regional/global scale, high-quality laboratory data can be used as a salient point in concert with data from surveillance and other systems to inform decisions to curb the disease.	Ensuring results are automated and interoperable with other systems improves coordination with reference laboratories and other digital health tools. As the outbreak continues, ensuring operational processes are robust and quality of data is maintained is important for countries.	As cases rise (potentially faster than initial waves), laboratory systems can harness advanced technologies in laboratory information systems, including computerized order entry, automated script triaging, sample tracking, flagging statistical outliers, and automated messaging to health workers and/or clients.
Learning and training	Support health worker readiness, including improved client data collection and sample testing.	Systems or tools that deliver new content or reinforce learning using mobile phones, tablets, or computers, including localized e-learning solutions for health workers and others.	Using digital platforms, such as online learning and mobile learning technologies, can increase the efficiency and effectiveness of capacity-building and training activities. As new diseases are detected, digital tools can be used to educate health workers about the new disease, symptoms, and treatment.	As cases are confirmed, connecting with health workers via SMS is important to quickly share more information about the outbreak, symptoms, treatment, and how to protect themselves.	**As cases rise, training health workers on national and international protocols using digital tools can equip providers with essential information about the disease. SMS can also rapidly share information with health workers from the ministry of health or World Health Organization about disease protection, treatment, and recovery efforts.**	High numbers of cases impact other health services. Digital tools can be used to train providers when task shifting forces some health workers to take on new services as well as where health services related to the disease outbreak expand.	Where vaccines are ready to be deployed, digital tools can educate frontline health care workers about administration, side effects, and other essential information about vaccine delivery as well as ongoing treatment for the disease.	**Scientists will identify more information about co-morbidities, side effects, and new treatments related to the disease. As the cases potentially rise again with this new evidence, training health care workers through digital tools can ensure they receive validated information about the disease as more is known about the impact on patients.**
One Health	Detect zoonotic disease outbreaks.	Digital systems supporting One Health integrate human, animal, and environmental (e.g., climate, natural disasters) data to predict risks and identify zoonotic disease outbreaks early. These systems include modeling, machine learning, and artificial intelligence (AI) techniques that can help preempt outbreaks by deploying preventive measures early. These systems also integrate real time surveillance between human and animal health disease reports to identify cases early, and often before spillover into human populations.	**Digital systems supporting One Health can identify morbidity and mortality in animal populations caused by known or new zoonotic pathogens and shared through integrated platforms allowing for earlier identification of infectious disease threats prior to emergence of human cases. These systems can track pre-identified priority zoonotic pathogens within animal populations. High-priority zoonotic diseases should be tracked in each country and data shared with the relevant health sector. As detection of a disease is initially identified, integrated systems can be useful to collect and manage data, helping to better understand the origins of the disease.**	High-priority zoonotic diseases should be tracked in each country and data shared with the relevant health sector. Digital surveillance tools used for animal health surveillance can be integrated for One Health surveillance.	As cases rise in a country, data should be reviewed using a One Health approach, optimizing processes for integrated data exchange between human and animal digital systems. Digital One Health tools can identify movement of disease to new areas through capture of cases in animal populations.	Digital tools assist in identifying and tracking potential movement of the disease through global animal population movements, incorporating surveillance at points of entry for animal populations to provide important data on disease spread.	Multisectoral discussions should continue once the initial outbreak wave is complete, especially if animal reservoirs play a significant role in disease emergence or spread. Data sharing and promotion of interoperability between animal and human health systems should be emphasize here to promote a robust One Health approach for improved performance to mitigate future outbreak events.	As cases increase, multisectoral stakeholder engagement and use of digital tools across human and animal health can once again provide early warning and identification of disease spread. Advanced modeling like machine learning and AI can help scientists better understand the disease, informing research into treatment and different strains of a virus that may emerge.

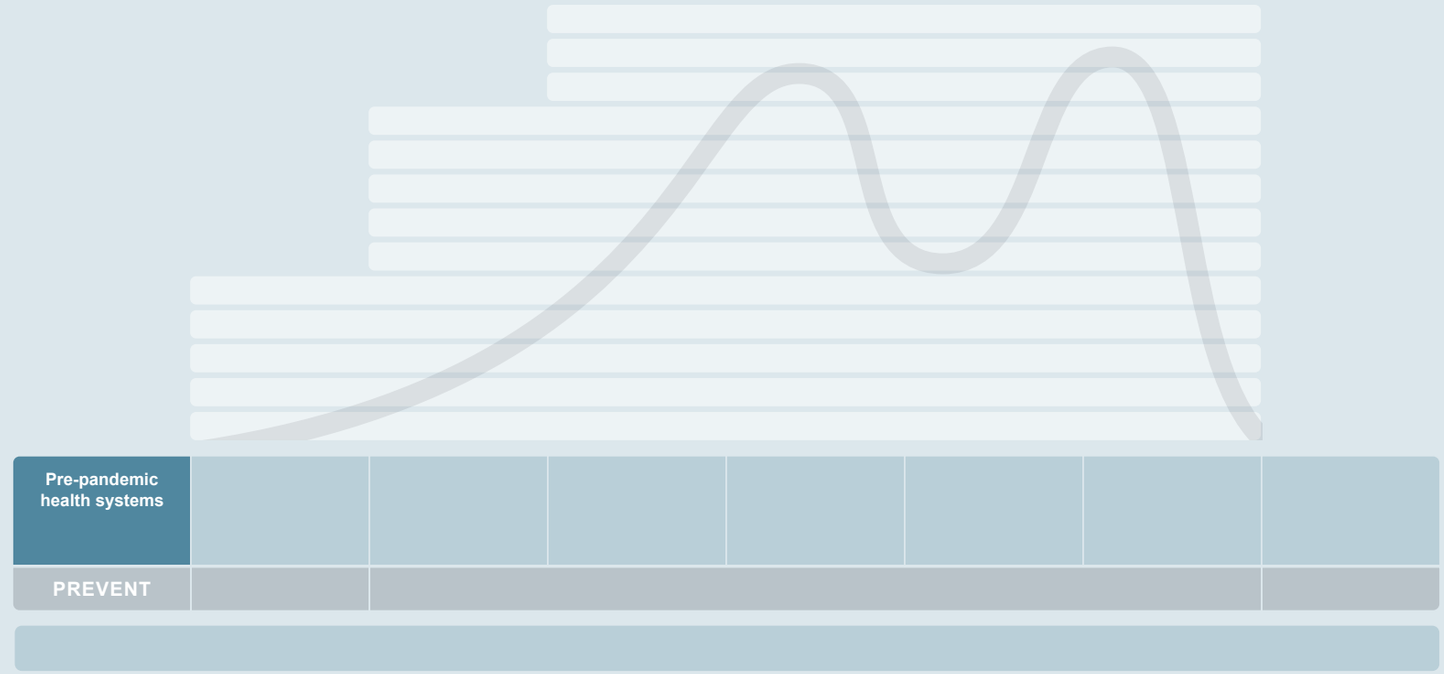
Digital tools that should be in place to support a well-functioning health system

What digital health systems and tools should be in place prior to a pandemic?

A mix of digital health tools should be in place prior to a pandemic, allowing for a “steady state” of the use of a tool and its data. Institutionalized tools are more easily and strategically adapted during a crisis like a pandemic.

“Steady state” activities to strengthen a country’s prevention, preparedness, and response in an epidemiological crisis

- Ensure digital health systems are equipped to collect, analyze, and synthesize high-quality scientific data.
- Develop and operationalize National Digital Health Strategies as a key component of health systems policies/strategies that articulate how and what types of digital tools should be harnessed for prevention, detection, and treatment of communicable diseases.
- Prioritize use of digital tools that use open data standards enabling data exchange.
- Deploy national data exchange repositories (e.g., product registries, facility registries, and client registries) to improve data quality and tool interoperability.
- Integrate predictive and early warning capabilities including signaling to improve health system responsiveness at the national and subnational level.
- Employ digital health tools to increase community and individual engagement in disease prevention efforts (e.g., risk communication and community engagement tools).
- Utilize digital health tools to strengthen cross-border surveillance and data sharing.
- Deploy digital health tools to promote One Health approaches to prevent emergence and spread of zoonotic diseases.
- Have in place the following: strong governance, legal frameworks, standardized infrastructure, interoperability, partnerships and coordination, and sustained financing.
- Strengthen the health system to produce reliable routine health data, fortify the vital registration and census data, and map capacity and laboratory equipment of health facilities.

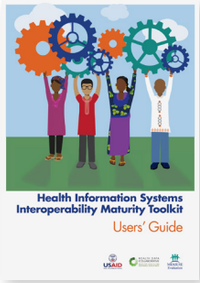


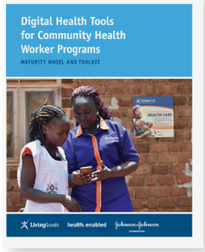
Rebuilding and strengthening health systems

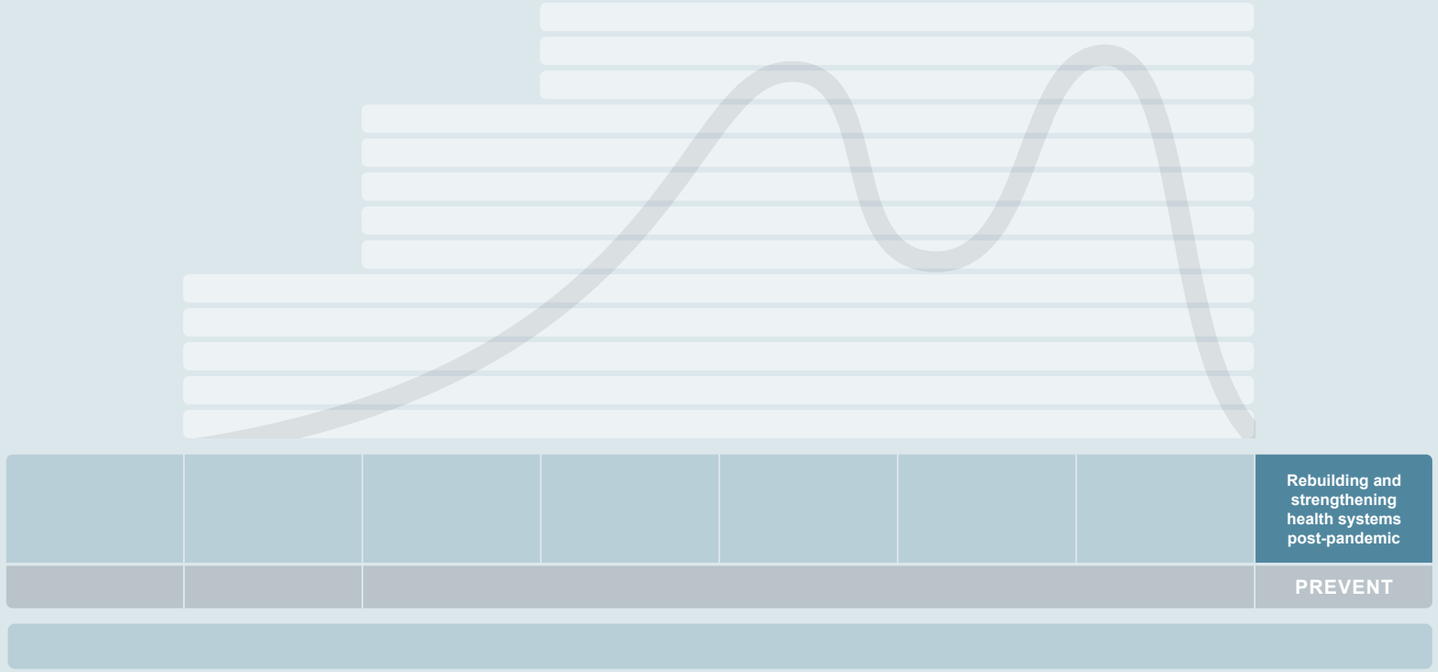
What should countries do post-pandemic to assess and strengthen the resiliency of a health system?

To rebuild and strengthen health systems post-pandemic, countries should assess and improve the utility of their tools deployed across health services. Strategies to strengthen health systems include conducting data quality assessments, improving systems interoperability, performing software upgrades, strengthening sustainable financing, modeling for digital health systems, and prioritizing improvements in digital infrastructure. Governments should also revisit national strategies and policies, making updates where needed. Emphasis should be on institutionalizing governance capacity to continue digital transformation.

To help assess and plan for improving digital health systems, countries can use stakeholder-vetted maturity models and toolkits such as the Health Information System Stages of Continuous Improvement Toolkit, the Health Information Systems Interoperability Maturity Toolkit, or the Digital Health Tools for Community Health Worker Programs Maturity Model and Toolkit. These resources can help countries assess, plan, and prioritize interventions and investments to strengthen their HIS.







Foundational focus

Data science assets

Data science assets are the tools, resources, and approaches that support the intentional and integrated use of data to produce actionable insights that strengthen health systems. Data science assets are vital to prevent and manage current and future outbreaks throughout all phases of the pandemic.

Data science asset examples

- Analytics training materials
- Automated SMS communication
- Automated workflow
- Cloud-based data services
- Custom algorithms
- Data blending tools
- Data insights
- Data management/ business processes
- Data use tools
- Data visualization
- Database management system
- Decision support tool
- Hosting services
- In-memory analytics
- Location data
- Mobile data collection tool
- Predictive models
- Research methods
- Research protocols
- Satellite imagery
- User-centered/people-centered design

The table to the right provides examples of data science assets overlaid onto the DATEC to demonstrate how they cut across all pandemic phases and describes why it is important to analyze, visualize, and act on the data that exist throughout each phase.

Pre-pandemic health systems	Initial detection of disease	Early outbreak/ low # of confirmed cases	National scale/rise in # of confirmed cases	Regional/ global scale of outbreak/high # of confirmed cases	Completion of initial outbreak wave	Resurgence of cases nationally	Rebuilding and strengthening health systems post-pandemic
PREVENT	DETECT	RESPOND					PREVENT
Data science assets							
This relates to the need for a strong foundation of eHealth building blocks to underpin ability to analyze data, e.g.: • Infrastructure (electricity, connectivity) to support data analytics at all levels of the health system. • Workforce trained in data analytics. • Data governance promotes data use at each level of the health system.	Data from surveillance systems are routinely analyzed, visualized, and reviewed to detect disease.	Data collection tools are adapted to capture case data about the disease and analytics used to tailor response efforts by geography.	Case data combined with location data and/ or satellite imagery helps identify and target “hot spots.”	Data blending tools and hosting services are necessary to combine data across systems.	Use existing data to create predictive models for who is at highest risk of infection in the next disease wave.	Utilize data analysis and visualization to target outbreak response and resources in “hot spots.”	Ensure relevant data analyses/ visualizations are integrated into routine systems.

Foundational focus

Interoperability

Interoperability of systems allows harmonized data exchange between digital health information systems. Interoperability allows countries to leverage existing infrastructure to rapidly adapt to new needs that arise during a pandemic. It enhances views of data, allows rapid uptake of tools deployed for emergency response across the epidemiological curve, and improves overall decision-making for health interventions.

Interoperability is facilitated by a well-designed architecture allowing exchange of data. **Terminology services** allow for comparable naming across systems, which enables homogenization of data and can allow for rapid mapping of data from different systems to register and identify patients, for example. **Health data standards** such as the Fast Healthcare Interoperability Resources (FHIR) also facilitate interoperability and reduce the need for governments or partners to build connections of systems, rather allowing innovators to adopt existing standards and not re-create solutions.

The visualization to the right shows that interoperability cuts across all phases of the DATEC and all systems within the health space. The descriptions in the table provide examples of how interoperability facilitates function in each phase.

OpenHIE is an example of a global community of practice that enables large-scale health information interoperability. During COVID-19, the World Health Organization and Digital Square established the OpenHIE COVID-19 task force in response to the interoperability and data sharing needs of the global community. The task force is working to:

- Identify and collate information relating to data standards and exchange.
- Identify gaps in and establish standards for data exchange priorities.
- Provide documentation and guidance (for open source software tools managed by the global good community and proprietary software tools) to improve adherence to these standards.
- Ensure that rapidly deployed solutions can be integrated into national digital health architectures.

Pre-pandemic health systems	Initial detection of disease	Early outbreak/ low # of confirmed cases	National scale/rise in # of confirmed cases	Regional/ global scale of outbreak/high # of confirmed cases	Completion of initial outbreak wave	Resurgence of cases nationally	Rebuilding and strengthening health systems post-pandemic
PREVENT	DETECT	RESPOND					PREVENT
Interoperability							
To enable a holistic view of health systems, it is vital to have connected systems that share data in a standardized format against an agreed/common architecture.	An example of how interoperability facilitates data exchange at this stage includes observational cases/diagnosis being reported from multiple systems to enable triaging and reporting. Interoperability will allow for the creation of a notifiable event that spans all connected systems in the digital health space.	Linking data from labs, field workers, primary clinics, hospitals, and other systems allows for an up-to-date mapping of the outbreak and facilitates analytics to better inform decisions on population management and health controls. Interoperability allows for a faster response effort to signal outbreak mitigation efforts in specific communities.	Linking caseloads to health worker scheduling and supplies facilitates informed operational decisions. Connected systems enable the ability to provide ongoing continuous treatment of patients and in the broader population through follow-up among community systems and clinics/hospitals.	Accurate holistic data enable countries and regions to confirm and track disease spread. The facilitation of cross-border data exchange policies and protocols allows for regional support and tracking, especially of mobile populations.	Flow of data through supply chain, clinical systems, analytics engines, laboratory systems, etc. supports monitoring the reduction of the initial wave and provides opportunities for rapid evaluation of effectiveness of interventions from a data-driven aspect.	Connected systems allow for monitoring and tracking of resurgence events and allow for operational decisions to rapidly address the resurgence wave.	Learnings from data flows from each system and updated protocols flow into each group to better align the health systems to address future outbreaks. Connected systems continuously feed outbreak and reporting monitoring systems to proactively identify potential threats.

Foundational focus

Routine surveillance

Routine surveillance is critical to protect communities on national, regional, and global scales. Digital tools and applications enable countries to more efficiently and quickly target resources and evaluate programs. Digital health tools collect patient-level and aggregate surveillance data daily, weekly, monthly, and/or quarterly. Surveillance systems are integral to global health security.

Health system managers and leaders who use public health surveillance as a management tool must recognize that political support and human and financial resources are essential to the sustainability of strong routine surveillance systems.

It is important for the national governments and the digital health community to:

- Modernize infectious disease surveillance tools to drive public health action.
- Strengthen routine information available on the population (e.g., accurate census data, vital registration data, mapping of health facilities and their services).
- Integrate animal and human health data, particularly information on livestock.
- Train the health workforce on how to capture and use routine surveillance for disease control and prevention.
- Use digital health tools to analyze, visualize, and share surveillance data with stakeholders.
- Ensure surveillance systems across public and private sectors routinely share health information and use it for decision-making.
- Utilize surveillance information to optimize health system performance and resource use.

Utilization of outbreak control tools across DATEC

This visual depicts how three categories of outbreak control tools are developed, deployed, distributed, and scaled throughout the phases of the epidemic, namely: diagnostics, therapeutics, and vaccines. The three top rows depict categories of outbreak control tools and describe at a high level how digital health tools can bolster pandemic response efforts during each phase.

Vaccines
(e.g., preparation for vaccine deployment and tools to support scale-up through phased distribution)

Therapeutics
(e.g., supplemental oxygen, emergency use antivirals, convalescent plasma/antibody treatments)

Diagnostics
(e.g., nucleic acid tests, direct antigen tests, serologic/antibody tests, biorepository)

	Pre-pandemic health systems	Initial detection of disease	Early outbreak/low # of confirmed cases	National scale/rise in # of confirmed cases	Regional/global scale of outbreak/high # of confirmed cases	Completion of initial outbreak wave	Resurgence of cases nationally	Rebuilding and strengthening health systems post-pandemic
	PREVENT	DETECT	RESPOND					PREVENT
Vaccines			Manage data while vaccine development is underway; begin prioritizing phase 1 recipients of vaccine.	Harness data science tools used to manage large amounts of testing data of vaccine efficacy.	Use digital tools to prioritize deployment such as health workers and monitor early deployment of vaccine, including clinical trial cohorts.	Deploy digital tools such as supply chain, electronic registries, client communication tools, etc. Ensure interoperability of data for efficient distribution and tracking of vaccine administration.	Monitor, deploy, and follow up to ensure safe, fair deployment of vaccines to all communities.	
Therapeutics			Capture data in case management, wearables (e.g., smartwatches), and other relevant systems for treatment interventions including side effects.	Add new therapeutic interventions to case management systems; utilize robust analytics on treatment.	Allow case management systems to include various treatment options; scale data collection of side effects as therapeutic interventions scale.	Harness digital case management tools to track administration and side effects; enable interoperability with electronic medical records and other tools.	Use data from digital tools to understand which treatment protocols are most effective in concert with monitoring treatment needs as vaccines are deployed.	Improve therapeutic interventions for future outbreaks; continue research to understand efficacy of therapeutics.
Diagnostics	Conduct research and development (R&D). Use digital tools for data collection and analysis.	Identify screening and diagnostic testing tools for new pathogen and ensure access to patient identification tests; screening, triaging, and point-of-care tests; and confirmatory tests.	Prioritize rapid diagnostics to quickly confirm cases.	Accelerate interoperability of diagnostics with lab information systems and connected devices to detect patterns of population incidence for epidemiological investigation.	Accelerate interoperability of diagnostic tools including new diagnostics that enter the market.	Continue to accelerate interoperability of diagnostic tools including new diagnostics that enter the market.	Continue to deploy the best technologies; ensure availability of diagnostic tools at all levels of health system.	Improve, enhance, and accelerate interoperable digital diagnostic interventions.

Impacts on health systems during a pandemic

This visual details examples of impacts on health systems at different phases of a pandemic. Digital tools can be used to mitigate these impacts. This is not an exhaustive list, yet this part of the framework can guide investments in digital tools to alleviate health system challenges. Below are broad categories of challenges on health systems and examples of approaches that can be taken overcome them.

Demand on facilities, equipment, and supplies

Example approach: Demand on health facilities can be felt at all times during a pandemic, especially as confirmed cases increase nationally and regionally. Logistics management information systems can help ensure facilities plan ahead to have sufficient stock of supplies to meet the increased demand in services.

Health workers and clients

Example approach: Health worker shortages, especially in areas where there are already insufficient numbers of qualified health workers, can be felt more intensely during an outbreak as health workers are lost to sickness, are overburdened by increased workload, and are faced with burnout. Digital learning and training tools can support task-shifting and also provide strategies for health workers to cope with workload and task management and to address mental health.

Outbreak control tools (diagnostics, therapeutics, vaccines)

Example approach: Therapeutics can often be costly for clients, especially as new treatments enter the market for new diseases. Digital financial services can help clients facing financial burdens from disease treatments.

Public health communication/policy

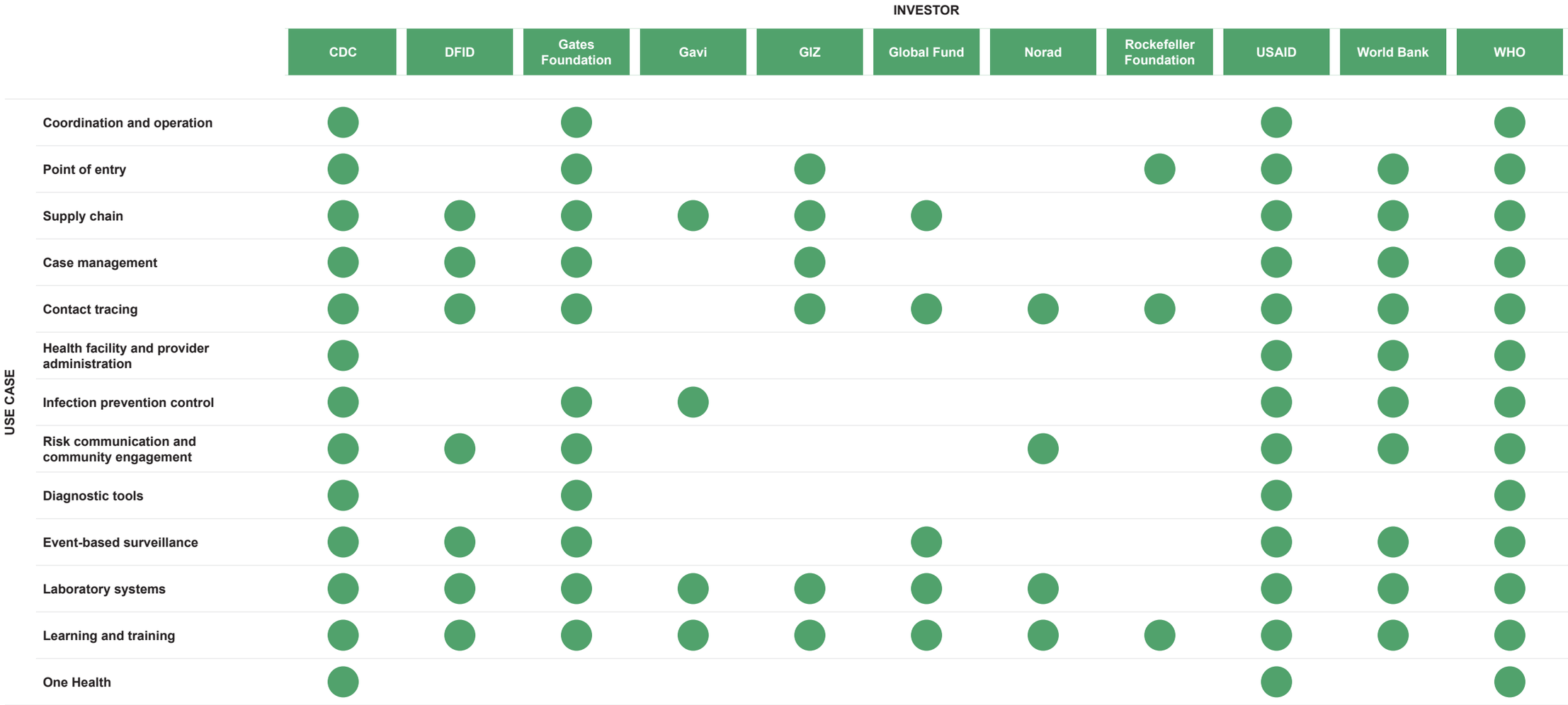
Example approach: Where vaccines are ready to be deployed later in an outbreak, electronic immunization registries are existing digital tools that can be adapted and scaled to support distribution to clients.

Other

Example approach: Some digital tools, especially those used at community level, have tasking prioritization features to help adapt delivery both for primary health care and response to an outbreak. These tools can be used especially as outbreaks begin significant disruption to primary health services like antenatal care and immunization.

Initial detection of disease	Early outbreak/low # of confirmed cases	National scale/rise in # of confirmed cases	Regional/global scale of outbreak/high # of confirmed cases	Completion of initial outbreak wave	Resurgence of cases nationally
Surge of testing could impact availability of staff and supplies at health facilities. Laboratories may not be equipped to handle specimen testing for a new disease or disease variant.	Surge requests for facilities (e.g., hospital beds), equipment (e.g., ventilators), and supplies (e.g., protective equipment).	Compromised safety of health workers.	Demand for facilities (e.g., emergency rooms, inpatient beds), equipment, and supplies exceeds supply.	Health workforce shortages exacerbated as health worker attrition increases. Increased mental health needs for general population.	Demand for facilities (e.g., emergency rooms, inpatient beds), equipment, and supplies threatens to exceed supply.
	Reduced availability of health workers.	Surge requests for therapeutics disrupting the supply chain. Surge in demand for psychosocial support (e.g., helplines, call centers, mental health chatbots).	Increased health worker burnout, mental health issues, and anxiety.		Need for health workers to be trained in vaccine deployment and storage of vaccines; ensuring available vaccine stock and commodities like gloves, syringes, etc. High mental health burden of health workers.
Health workers may be unfamiliar with symptoms or testing protocols for new and emerging diseases. Clients may present symptoms for new disease without awareness of the disease. Client may mistake symptoms for another health issue and be in need of tools to help them become better educated about and able to identify the new disease.	Increased need for diagnostic tools. Increased financial burdens for clients and growing need for financial support that can be facilitated through digital financial services for health. Surge in anxiety, mental health issues, and violence that affects health workforce and general population.	Governments enact policies (e.g., travel bans).	Surge requests for diagnostics resulting in delays; rapid introduction of new diagnostic tools which may require health worker training. Surge requests for therapeutics resulting in insufficient supply; rapid increase of new therapeutic treatments and guidelines which require health worker training.	Pandemic fatigue results in need to reinvigorate public to prevent disease transmission. Misinformation/ politicization about risk of disease transmission is widespread, resulting in unnecessary risk of infection, confusion, anger, mental health concerns, etc. Regulatory agencies and governments prioritize vaccine deployment.	Surge requests for vaccine deployment coupled with need for demand-generation activities where there is vaccine distribution. Prioritization of vaccine cohorts where there are shortages of vaccine supply. For multi-dose vaccines, processes for tracking vaccine administration and ensuring patients attend to follow-up.
Regulatory agencies (e.g., multilateral, national) communicate normative guidelines to minimize risk of disease transmission.	Increased need for management of misinformation coupled with tailored and targeted public health information.	Disruption to primary health care services and testing and treatment for HIV/AIDS, malaria, and other communicable diseases. Increased need for remote health care delivery (e.g., telemedicine, helplines, call centers, ePrescriptions, eSick-leave).	Disruption to primary health care services causes system to adapt care delivery (e.g., increase demand for telehealth and home care).		Misinformation/ politicization of disease continues.
	Increased use of surveillance tools and need for additional contact tracing labor.				

Investor coordination across DATEC



Abbreviations: CDC: Centers for Disease Control and Prevention, DFID: UK Department for International Development, GIZ: German Corporation for International Cooperation, USAID: United States Agency for International Development, WHO: World Health Organization.

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Digital Square is a PATH-led initiative funded and designed by the United States Agency for International Development, the Bill & Melinda Gates Foundation, and a consortium of other donors.

This resource is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of PATH and do not necessarily reflect the views of USAID or the United States Government.