Measuring Preparedness for Public Health and Health Care Emergencies

The Current State of Preparedness Metrics in the United States and Considerations for the Future

Report submitted August 30, 2024

Submitted to:
Allison Kolbe
Office of the Assistant Secretary for Planning and Evaluation (ASPE)
U.S. Department of Health and Human Services
200 Independence Ave. S.W.
Washington, DC 20201

Work performed under:
Contract No. HHSP233201500035I, Task Order No. 75P00122F37070

Authors
Katie Morrison Lee, MPP, Sue Felt-Lisk, MPA, Camille Veri, MPA, Sheila Hoag, MA, Emily Crabtree, MPH

Acknowledgments
The authors wish to thank the Technical Expert Panel members (Appendix D) for their valuable contributions to this work, as well as Chris Palo, Effie Metropoulos, Jill Miller, Dorothy Bellow, and Sheryl Friedlander at Mathematica. We would also like to acknowledge the following individuals:

Kevin Yeskey, MD, MDB Inc.
Nicholas Cagliuso, PhD, MPH, MDB Inc.
Allison Kolbe, PhD, ASPE
Deborah Porterfield, MD, MPH, ASPE
Contract Officer's Representative, Marsha Clarke, PhD, ASPE
Kim Nguyen, DVM, MPH, ASPE
Kathleen Miller PhD, MS, ASPE
Laurin Grabowsky, MSc, ASPE
Jessica White, MPP, ASPE

Contents

Exhibits

Executive Summary

A. Background

A wide range of recent domestic disasters—from wildfires to the COVID-19 pandemic—have highlighted the challenge of preparing for large-scale public health emergencies. Inadequate preparation for these disasters has resulted in preventable loss of life, diminished public trust in federal, state, tribal, local, and territorial (STLT) governments, and ongoing confusion about actions needed to improve preparedness.

To help the federal government and STLT jurisdictions better prepare for emergencies, there is a need to understand how prepared different jurisdictions are for various emergencies. Understanding a jurisdiction's level of preparedness can inform resource allocation and identify actions that the federal government and STLT jurisdictions can take to bolster preparedness, such as developing formal response plans, training public health and health staff, or forming contractual agreements with partner organizations. However, assessing whether a jurisdiction is prepared for different emergencies is inherently complex and there is a lack of consensus among practitioners and scholars on how to approach preparedness measurement. Measurement tools introduced in recent decades have numerous limitations, such as inconsistently defining preparedness and its goals, relying on subjective agency assessments of the standards and capabilities that contribute to preparedness, and failing to provide an evidence base for measures. The cross-sectoral, cross-jurisdictional nature of public health systems adds to the complexity of preparedness measurement: because of the many agencies and organizations involved in emergency response efforts, it is challenging to understand how performance should be measured and accountability distributed across these partners. Further, the singularity of public health emergencies makes it difficult to assess whether key takeaways from one disaster will apply to the next.

In response to these challenges, the U.S. Department of Health and Human Services Office of the Assistant Secretary for Planning and Evaluation (ASPE) funded a study to address 1) the current state of metrics for public health and health care preparedness in the United States, including gaps in existing metrics and limitations of existing metrics identified during the COVID-19 pandemic and 2) strategies to potentially improve measurement of public health and health care preparedness and address the gaps and limitations in current metrics. The methods for this study include a synthesis of key findings from a targeted environmental scan of domestic preparedness metrics and a technical expert panel (TEP) made up of representatives from federal agencies, public health and healthcare organizations, and academic institutions, with diverse experience in preparedness measurement and emergency response.

B. The current state of public health and health care preparedness metrics in the United States

We conducted an environmental scan to understand tools currently available to assess STLT preparedness, including indices, measure sets, and other instruments such as self-administered preparedness surveys.[I] We identified nine tools to measure STLT emergency preparedness, including three that have also been used to assess national preparedness in the United States (Exhibit ES.1).

[I] We define indices as tools that assess preparedness across a range of measures and create a composite score summarizing a jurisdiction's preparedness. Measure sets similarly assess preparedness across a variety of measures but do not produce a summary statistic.

Exhibit ES.1. List and description of tools to assess STLT public health and healthcare preparedness

Tool	Description
Tools for internal and external stakeholders	
Community Outbreak Preparedness Index (COPI)	Assesses county-level preparedness for infectious disease outbreaks using publicly available data
Hospital Medical Surge Preparedness Index (HMSPI)	Evaluates the capacity of hospitals to handle patient surges during mass casualty events, using over 120 measures from publicly available data sources
Hospital Preparedness Program (HPP) performance measure set	Assesses preparedness of HPP funding recipients based on 22 performance measures reported by recipients and disseminated broadly
National Health Security Preparedness Index (NHSPI)	Generates a composite preparedness score for states, territories, and the nation overall based on 130 measures derived from publicly available data sources
Trust for America's Health (TFAH) Ready or Not tool	Evaluates states' preparedness for public health emergencies using a targeted set of 10 measures largely derived from the NHSPI
Self-administered tools for internal use by STLT jurisdictions	
Assessment for Disaster Engagement with Partners Tool (ADEPT)	Summarizes the frequency and nature of activities related to disaster preparedness, response, and recovery that local health departments engage in with community-based organizations, using a 15-item index for use by local health departments
Connectivity Measurement Tool	Quantifies the level of connectivity of different organizations and systems involved in public health preparedness across 28 items
Preparedness Capacity Assessment Survey (PCAS)	Creates an aggregate score summarizing preparedness of local health departments
Rapid Urban Health Security Assessment (RUHSA)	Evaluates local-level health security capacities across 46 measures

We present a summary of key characteristics of these tools, as well as gaps and limitations as identified by the literature and the TEP, in Exhibit ES.2.

Exhibit ES.2. Summary of key characteristics of existing public health and health care preparedness metrics and their gaps and limitations

Characteristic	Summary of existing metrics and their gaps/ limitations
Purpose and users	Tools vary in their target audience: • Five tools are intended for internal and external stakeholders. Results from these tools are publicly disseminated for use by a broad audience of federal and STLT policy makers, public health and health care organizations, and the general public. • Four tools require self-administration and are intended for internal users, such as local health department staff and their partners. **Gaps and limitations:** Tools intended for broad internal and external audiences may not feel actionable for STLT users that face challenges interpreting and adapting scores to their local contexts.

Characteristic	Summary of existing metrics and their gaps/ limitations
Jurisdiction levels	Of the nine STLT tools: • Two tools (the NHSPI and the TFAH tool) assess preparedness at the state and territorial level; in addition, the HPP measure set can be aggregated at the state level. • Seven tools assess preparedness within states and territories at the local level (e.g., county, local health department, or hospital level). • Results from two tools—the NHSPI and HPP measure set—are routinely aggregated at the national level to present a snapshot of national preparedness. In addition, the TFAH tool groups states into tiers based on scores for each measure, which can be used to assess national preparedness (for example, by assessing the number or percentage of states in the highest or lowest performing tier for each measure to assess relative strengths and weaknesses across the United States). • None of the tools were adapted for tribal communities. **Gaps and limitations:** There is no comprehensive all-hazards index to measure and guide local jurisdictions' emergency preparedness efforts. In addition, there were no preparedness tools tailored to tribal communities.
Factors measured	Tools vary in the breadth of factors that they measure. For example: • The NHSPI and COPI take a comprehensive approach to measuring preparedness across the emergency management cycle (i.e., prevention, protection, mitigation, response, and recovery) and include "proactive" measures of preparedness that assess social vulnerability and resilience. • Other tools are more focused on specific aspects of preparedness (for example, the HMSPI focuses on surge capacity and the Connectivity Measurement Tool focuses on perceptions of partnerships). **Gaps and limitations:** Existing tools inadequately capture several important factors that affect preparedness, including strength of cross-sector collaboration, individual readiness and training of the workforce, administrative capacity, political factors, social vulnerability, and public trust.
Types of disasters addressed	Eight out of nine preparedness tools take an all-hazards approach to measurement, assessing measures of preparedness applicable to a wide range of disasters. **Gaps and limitations:** There is a lack of disaster-specific tools; all-hazards tools may not reliably predict outcomes for all types of emergencies and may be challenging for STLT users to interpret.
Data sources and availability	Four tools leverage data from nearly 100 different public sources, including national surveys, government agencies, and associations; the other five tools are designed for self-reporting/self-administration. **Gaps and limitations:** There is a lack of publicly available data at the local level. In addition, there are limitations in the availability of timely data, with some sources being updated infrequently.

In addition to the gaps noted above, the COVID-19 pandemic exposed other weaknesses that need to be addressed to improve emergency preparedness and preparedness measurement. For example:

/ Many preparedness tools—including the NHSPI, TFAH, and other prominent global tools—were not valid predictors of COVID-19 outcomes, such as excess mortality rates. This underscores the need to explore ways to improve measurement within existing tools and consider whether all-hazards tools like the NHSPI are the best way to assess preparedness for the wide range of unique emergencies that the country is likely to face.

/ A variety of critical factors that affect outcomes are not accounted for in current preparedness measures, such as partnerships, political will, and public trust, among others. Moving forward, it will be important to consider ways to measure these factors and incorporate them in preparedness metrics.

/ The disparate impacts of the COVID-19 pandemic on socially vulnerable communities, who suffered higher incidence of COVID-19 infections and deaths, highlight the need to embed equity in how

jurisdictions prepare for emergencies and thus, in how we measure communities' preparedness and assess their vulnerabilities.

/ Finally, the COVID-19 pandemic exposed significant weaknesses in the public health data and surveillance infrastructure, as evidenced by challenges with reporting and tracking lab test results, lack of interoperability across health and public health reporting systems, and gaps in the types of data that are collected and tracked. Investments in data infrastructure could help improve preparedness metrics, especially at the local level where measurement is limited by the availability of standardized, timely data.

C. Strategies to improve measurement of public health and health care preparedness

Given the gaps and limitations in existing tools and inherent challenges in measuring preparedness, there is an opportunity to apply lessons learned from the COVID-19 pandemic to pursue development of improved metrics. These efforts must be rooted in an understanding of the ideal attributes of public health preparedness measures, so that there are set criteria against which future metrics could be evaluated. We present ten attributes in this report, informed by current public health performance measurement literature. Then, considering these key attributes and feedback from the TEP, we outline four strategies and examples of associated follow-up efforts that could potentially advance preparedness measurement, summarized in Exhibit ES.3.

Exhibit ES.3. Four strategies that could potentially advance preparedness measurement, and potential follow-up efforts for consideration

Strategies	Potential follow-up efforts
1. Address gaps in existing metrics by developing or refining important measures of preparedness and supplementing preparedness metrics with contextual data.	Low-intensity efforts could include: • Advancing individual training and measurement of training by working with professional associations. • Evaluating existing online preparedness curricula to set a foundation for measurement of individual preparedness. • Exploring degree program accreditation as a tool to improve readiness of future public health professionals and set a foundation for a national measure of individual preparedness. Medium-intensity efforts could include: • Developing new trainings to fill gaps, supporting improvement on future measurement of individual preparedness. • *Advancing measurement on the strength of essential partnerships* • *Investigating contextual factors critical to response and outcomes.* High-intensity efforts could include: • *Improving measurement of administrative response capabilities and providing support to help STLT jurisdictions overcome barriers.* • *Developing a national-level measure or measures corresponding to administrative response capability.*

Strategies	Potential follow-up efforts
2. Improve how health equity is addressed in preparedness metrics by engaging underserved communities in continuous efforts to advance measurement and considering social vulnerability data together with preparedness measures.	A low-intensity effort could include: • Developing recommendations for an effective approach to present social and health vulnerability indicators with or within preparedness indices. A medium- to high-intensity effort (depending on the number of communities included) could include: • Identifying locally appropriate metrics focused on health equity to advance equity-focused preparedness measurement in communities, such as metrics summarizing the preparedness level of neighborhoods disproportionately impacted by COVID-19 and at elevated risk for specific types of emergencies (for example, flooding in a low-lying area or floodplain).
3. Improve source data and use additional analyses to enhance the availability, responsiveness, and salience of preparedness metrics.	Low-intensity efforts could include: • Exploring the feasibility of using artificial intelligence with After Action Reports (AARs), to facilitate scaled up qualitative analysis to identify themes. • Exploring stakeholder receptiveness to implementing a metadata template for AARs, to facilitate synthesizing patterns across AARs. • Exploring the feasibility and benefits of using non-public data sources, such as data from the Real-World Incident Reporting and Evaluation tool or others, to advance the evidence base for preparedness metrics. Medium-intensity efforts could include: • Analyzing AARs on a large scale to identify key themes. • *Facilitating improvement of AARs' quality and availability, through an organized peer review process and support to ensure AARs are created and shared following all disasters.* • Undertaking research using non-public data sources to advance the evidence base for preparedness metrics. A high-intensity effort could include: • *Identifying and developing automated data solutions that would reduce reporting burden.*
4. Enhance actionability and understandability of metrics by developing and disseminating information on exemplars.	A low-intensity effort could include: • Conducting a needs assessment to identify jurisdiction types, organizations, and disaster types most in need of exemplar models, and a landscape assessment to identify existing strong examples and find important gaps. A medium-intensity effort could include: • Developing case studies to fill identified needs for exemplar models and disseminate them to relevant audiences.

Notes: *Low-intensity*=likely to require one to three staff working for less than a year; *high-intensity*=those that involve large-scale data collections or system changes; *medium-intensity*=efforts likely to fall between the low- and high-intensity ranges. Low-intensity and italicized efforts could begin when resources are available. Italicized medium and high-intensity efforts indicate those not dependent on low-intensity efforts. Medium- and high-intensity efforts not italicized would best be structured using results from the low-intensity efforts listed.

Implementing these strategies would require collaboration across a range of stakeholders, including federal agencies, STLT jurisdictions, public health and health care organizations and their partners, and researchers. In addition, these strategies would require investments that need to be considered against the many competing priorities that public health systems face. The low-intensity efforts listed above often set up and help structure suggested medium- and high-intensity efforts and would be good places to start. However, several of the suggestions for medium- or high-intensity efforts could begin without additional preliminary work as soon as resources permit; those are italicized in Exhibit ES.3. The specific

selection of where to begin depends, as a practical matter, on how managers within the relevant agencies find the efforts well-matched with existing work, resources, and program opportunities; but even implementing a few of the efforts listed in Exhibit ES.3 could help agencies make incremental progress. Ultimately, the availability of better tools to measure and understand gaps in preparedness against specific threats could inform federal and state resource allocation and help set priorities to improve preparedness of public health and healthcare system for the next public health threat. In the hands of strong leadership, better measurement can also catalyze and enable improvement, resulting in a better-prepared nation.

I. Introduction

A wide range of recent domestic disasters have highlighted the challenge of preparing for large-scale public health emergencies. Since 2020, the U.S. Department of Health and Human Services (HHS) has issued 57 declarations of new and continuing public health emergencies for a range of crises, including infectious diseases such as COVID-19 and monkeypox; natural disasters such as wildfires, hurricanes, and severe storms; and the ongoing opioid epidemic.[2,II] Inadequate preparation for these disasters has resulted in preventable loss of life; diminished public trust in federal, state, tribal, local, and territorial (STLT) governments; and ongoing confusion about the actions needed to improve public health and health care preparedness (Exhibit I.1).

Exhibit I.1. What is public health and health care preparedness?

Public health and health care preparedness is the ability of public health and health systems, communities, and individuals to prevent, protect against, mitigate, quickly respond to, and recover from health emergencies.[1]

Three federal agencies provide critical guidance and funding to help STLT jurisdictions and public health and health care systems nationwide advance emergency preparedness. The U.S. Centers for Disease Control and Prevention (CDC) and the Administration for Strategic Preparedness and Response (ASPR) maintain sets of core capabilities that public health and health care systems need to achieve preparedness. In addition, the Federal Emergency Management Agency (FEMA) maintains a set of 32 capabilities intended to guide emergency preparedness broadly at the community level, helping to achieve FEMA's National Preparedness Goal, organized across five mission areas (Exhibit I.2).[4] Collectively, since 2002, federal agencies, including CDC, ASPR, and FEMA, have distributed more than $75 billion in funding to help STLT jurisdictions and public health system partners prevent, prepare for, and respond to emergencies.[5,6,7]

Exhibit I.2. FEMA's National Preparedness Goal and the five phases of emergency preparedness

FEMA defines the **National Preparedness Goal** as "a secure and resilient Nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk."

FEMA further describes five categories, or "mission areas," needed to support this goal: [3]

1. **Prevention.** Ability to avoid, prevent, or stop imminent threats
   Example capability: *Intelligence and information sharing*
2. **Protection**. Ability to secure the homeland against acts of terrorism or disasters
   Example capability: *Supply chain integrity and security*
3. **Mitigation**. Ability to reduce loss of life and property by lessening the impact of disasters
   Example capability: *Community resilience*
4. **Response**. Ability to save lives, protect property and the environment, and meet basic human needs after an incident
   Example capability: *Public health, health care, and emergency medical services*
5. **Recovery**. Ability to help communities recover quickly
   Example capability: *Housing*

[II] This count includes both new public health emergency declarations and declarations that have been renewed by the Secretary of the Department of Health and Human Services for ongoing emergencies, such as the opioid crisis and COVID-19.

Because communities face distinct hazards, public health and health care emergency preparedness strategies vary from jurisdiction to jurisdiction. For example, a rural community in a low-lying coastal region would necessarily prioritize different preparedness capabilities than a landlocked city prone to tornadoes. While guidance from the CDC, ASPR, and FEMA is designed to support emergency preparedness across a broad range of disaster types (Exhibit 1.3), these agencies also encourage routine hazard or risk assessments to help communities understand distinct threats they face and prioritize capabilities based on local needs. FEMA requires government agencies to work with stakeholders to conduct a thorough community risk assessment every three years using the Community Threat and Hazard Identification Risk Assessment to guide their work.[9] Similarly, CDC's Public Health Emergency Preparedness (PHEP) program requires funded public health agencies to work with local jurisdictions and their community partners to conduct a risk assessment at least once every five years.[10] Risk assessments are also common at the facility (such as hospital or nursing home) level. For example, health care facilities that participate in Medicare or Medicaid are required to complete or update a hazard vulnerability analysis annually to better understand risks and prioritize activities to mitigate, respond to, and recover from these risks.[11]

Exhibit I.3. An all-hazards approach to preparedness

The capabilities advanced by CDC, ASPR, and FEMA are designed to be adaptable across all hazard types: natural disasters; infectious disease outbreaks; terrorist attacks; cybersecurity attacks; and chemical, biological, radiological, or nuclear incidents. This all-hazards approach to preparedness recognizes that "while hazards vary in source (natural, technological, societal), they often challenge health systems in similar ways and demand a multisectoral response."[8]

Preparing for emergencies requires planning and collaboration across a multitude of public and private sector partners that play distinct roles in public health and health care emergency response. For example, CDC's public health preparedness and response capability standards include STLT public health departments, health clinics, ambulatory care providers, fire departments, law enforcement agencies, public works, and other partners as contributors to medical surge capabilities; first responders, epidemiologists, environmental health agencies, clinical laboratories, and other partners as contributors to laboratory testing capabilities; and social service agencies, schools, community coalitions, mental health providers, housing programs, and other partners as contributors to community recovery capabilities.[12] Similarly, ASPR's Health Care Preparedness and Response Capabilities are designed for multisector health care coalitions (HCCs) consisting of public health agencies, hospitals, emergency medical services, and emergency management organizations located in a defined geographic location.[13]

The landscape of organizations that make up the public health system and contribute to public health and health care preparedness is varied and complex. Exhibit I.4 presents the broad network of partners involved in emergency preparedness and response. Partners range from health clinics and emergency medical services (EMS) that provide direct health care services, to employers and schools that play key roles in ensuring safe workplaces and learning environments, such as encouraging testing and vaccination, as many employers and organizations did during the COVID-19 pandemic.

Exhibit I.4. Entities that might make up a local public health emergency preparedness system

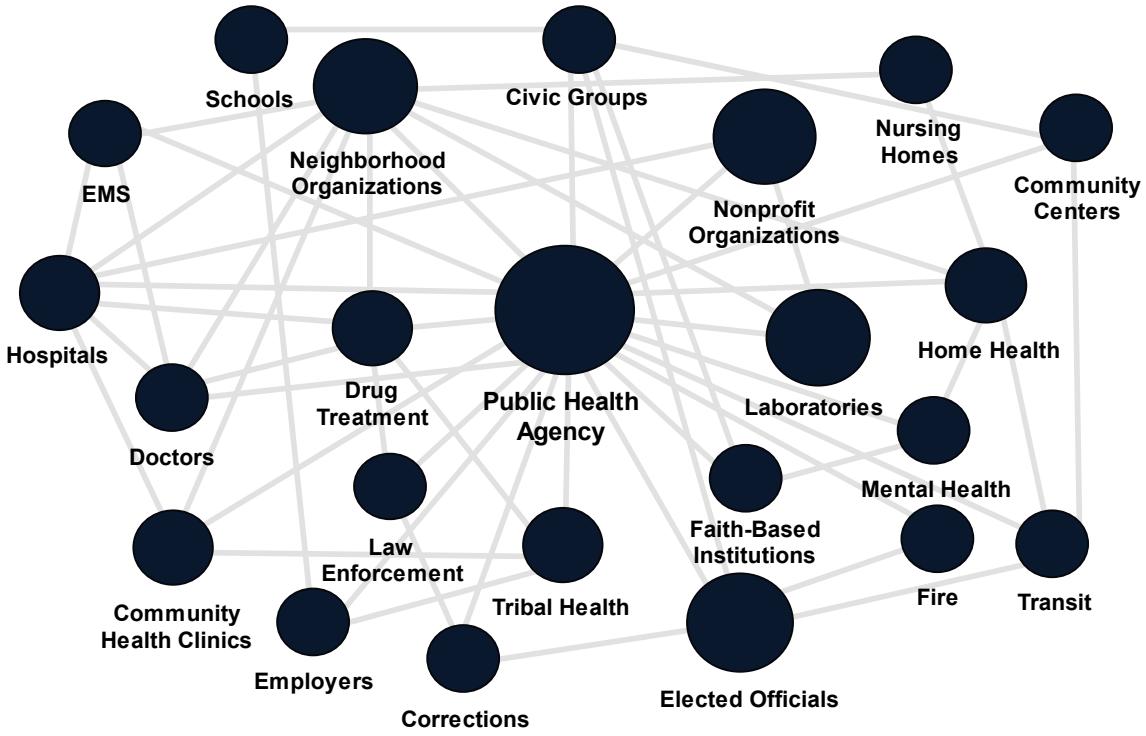


Image adapted from NACCHO, "Local Assessment Instrument." National Association of City and County Health Officials, 2013.

Assessing whether a jurisdiction is prepared for different emergencies is inherently complex, and there is a lack of consensus among practitioners and scholars on how to measure preparedness. Despite the promise and potential of preparedness measurement (Exhibit 1.5), tools introduced in recent decades have numerous limitations: inconsistently defining preparedness and its goals, relying on subjective agency assessments of the standards and capabilities that contribute to preparedness, and failing to provide an evidence base for measures.[15,16,17] The cross-sectoral, cross-jurisdictional nature of public health systems adds to the complexity of preparedness measurement; because of the many agencies and organizations involved in emergency response, it is challenging to understand how performance should be measured and accountability distributed across these partners.[18] The singularity of public health emergencies is a central challenge. Because

Exhibit I.5. Why measure preparedness?

Measuring preparedness can provide a powerful decision-making tool to guide strategies to ensure a community of any size is ready for an emergency. Stoto and Nelson[14] present three core aims of preparedness measurement:

1. **Accountability.** Measures can help hold leaders and public health system partners accountable for their investments in preparedness by allowing them to assess preparedness relative to set standards or benchmarks.
2. **Systems improvement.** Measures can highlight where weaknesses and gaps exist across the public health system, driving quality improvement efforts.
3. **Research and knowledge sharing.** Over time, as measures are tested and refined, they can help build evidence on "what works" when preparing for emergencies, which is key to informing the study of public health preparedness.

each disaster is unique, it is difficult to assess whether key takeaways from one disaster will apply to the next.[19]

The COVID-19 pandemic exposed flaws in U.S. emergency response systems, demonstrating the urgent need for more reliable, evidence-based preparedness measures. Public health and health care systems faced extraordinary pressures, from staffing a qualified workforce to meeting surging demand for medical care to addressing the stark health inequities that persisted across communities. Given the significance of the pandemic and its lasting impact, a close examination of current approaches to preparedness measurement, including key drivers of preparedness that may have been overlooked, is essential to inform readiness for infectious disease outbreaks and other potential disasters.

In response to the issues outlined above, HHS's Office of the Assistant Secretary for Planning and Evaluation (ASPE) funded this study, designed to draw lessons from the COVID-19 pandemic to inform efforts to measure preparedness going forward. The study included a targeted environmental scan of domestic preparedness metrics and a technical expert panel (TEP)—made up of representatives from federal agencies, public health and health care organizations, and academic institutions—with diverse experience in preparedness measurement and emergency response.

This report gives a comprehensive overview of the current landscape of preparedness measurement tools and suggests areas for improvement, exploring why current efforts to measure preparedness have failed to predict effective responses in real-world settings. In addition, to inform future measurement efforts, it reveals key criteria that preparedness metrics should meet and highlights strategies that could potentially advance measurement to meet these criteria and address the gaps found in current metrics of public health and health care preparedness.

The research questions in Exhibit I.6 guided this work. Questions 1–3 focus on current measures and are addressed in Chapter II; Questions 4 and 5 look to the future of public health preparedness measurement and are addressed in Chapter III. In addition, Appendix A describes the study methods, Appendix B describes existing tools to measure STLT emergency preparedness, Appendix C summarizes literature assessing how well preparedness indices predicted outcomes during the COVID-19 pandemic, Appendix D lists the TEP participants, and Appendix E provides the agenda for the TEP.

Exhibit I.6. Study research questions

1. What public health and health care preparedness tools are currently available in the United States? (Chapter II)
2. What are the gaps in existing public health and health care preparedness metrics? (Chapter II)
3. What lessons learned from the COVID-19 pandemic can inform measurement of emergency preparedness and response at STLT public health agencies in the future? (Chapter II)
4. What attributes should public health and health care preparedness metrics have, and what gaps would these attributes address? (Chapter III)
5. What strategies should potentially be explored to improve measurement of public health and health care preparedness? (Chapter III)

II. The Current State of Public Health and Health Care Preparedness Metrics in the United States

The nation's response to the COVID-19 pandemic provides an opportunity to better understand how to improve public health and medical response to all types of disasters, including infectious disease outbreaks, cybersecurity threats, and other emergencies. To seize this opportunity, we drew on findings from the environmental scan and TEP to address the following research questions, which are the basis of this chapter's structure:

1. What metrics on public health and health care preparedness are currently available in the United States?
2. What are the gaps in existing public health and health care preparedness metrics?
3. What lessons learned from the COVID-19 pandemic can inform measurement of emergency preparedness and response at STLT public health agencies in the future?

Exhibit II.1. Types of preparedness metrics

This chapter covers three types of metrics used to assess public health and health care emergency preparedness:

- **Measures** quantify specific aspects of emergency preparedness and response, such as whether a state has written disaster plans for long-term care and nursing facilities, or the percentage of adults receiving a seasonal flu vaccine.
- **Indices** create a composite statistic or score by collecting and aggregating data from multiple measures, helping audiences easily compare jurisdictions along various dimensions of emergency preparedness.
- **Measure sets** are lists of measures to help users quantify preparedness along various dimensions. Unlike indices, measure sets do not produce a composite score.

We use the term **preparedness tools** to describe indices and measure sets that assess preparedness across multiple measures.

Unless otherwise noted, this chapter focuses on tools that quantify preparedness in the United States across multiple phases of the emergency management cycle (that is, prevention, protection, mitigation, response, and recovery). We define preparedness tools as indices, measure sets, and other instruments (such as self-administered surveys) that are designed to quantify how prepared public health and health care systems are to respond to and recover from emergencies and disasters across multiple measures (Exhibit II.1). Exhibit II.2 and Appendix B summarize the existing STLT preparedness tools and serve as the foundation for the chapter. Given the study's focus on preparedness metrics in the United States, Exhibit II.2 and Appendix B exclude: (1) global tools used to measure preparedness in other countries or to measure nation-level preparedness (for example, the Global Health Security Index); (2) tools that focus on a single phase or aspect of the emergency management cycle (for example, resilience or vulnerability indices); (3) tools that assess but do not quantify preparedness (for example, FEMA's Community Threat and Hazard Identification and Risk Assessment, which describes a process communities can use to understand their risks and capabilities); and (4) tools that are not publicly accessible because they protected from disclosure under the Protected

Critical Infrastructure Information Program (for example, Cybersecurity & Infrastructure Security Agency's Infrastructure Survey Tool). [III]

A. What public health and health care preparedness tools are currently available in the United States?

In this section, we describe the tools that are currently available to assess STLT preparedness across multiple phases of the emergency management cycle. We focus on the following characteristics:

/ The number and types of tools

/ The tools' purpose and intended users

/ The jurisdiction levels the tools apply to

/ How existing tools conceptualize preparedness

/ The types of disasters the tools address

/ Sources of data used to quantify preparedness in the tools

1. Number and types of available tools

There are relatively few tools designed to measure STLT public health and health care preparedness in the United States. The environmental scan found just nine preparedness tools for use at the STLT level in the United States, of which three have been used to assess national preparedness (Exhibit II.2; Appendix B). Of the nine tools, six were indices that produced composite scores and three were measure sets. In addition, there were three sets of capabilities maintained by federal agencies, which we describe below, but do not include in the list of tools because they do not quantify preparedness. The literature also described a variety of tools to measure country-level preparedness; prominent examples are in Exhibit II.3.

Exhibit II.2. List and description of tools to assess STLT public health and healthcare preparedness

Tool	Description
Tools for internal and external stakeholders	
Community Outbreak Preparedness Index (COPI) [20]	Assesses county-level preparedness for infectious disease outbreaks using publicly available data
Hospital Medical Surge Preparedness Index[21]	Evaluates the capacity of hospitals to handle patient surges during mass casualty events, using over 120 measures from publicly available data sources
Hospital Preparedness Program (HPP) performance measure set[22]	Assesses preparedness of HPP funding recipients based on 22 performance measures reported by recipients and disseminated broadly
National Health Security Preparedness Index (NHSPI) [23]	Generates a composite preparedness score for states, territories, and the nation overall based on 130 measures derived from publicly available data sources
Trust for America's Health (TFAH) Ready or Not tool[24]	Evaluates states' preparedness for public health emergencies using a targeted set of 10 measures largely derived from the NHSPI

[III]Although we excluded these tools from the main analysis of themes and gaps presented in Chapter II, we reviewed and cite literature related to these tools as it relates to overarching themes and gaps in preparedness metrics.

Tool	Description
Self-administered tools for internal use by STLT jurisdictions	
Assessment for Disaster Engagement with Partners Tool (ADEPT) [25]	Summarizes the frequency and nature of activities related to disaster preparedness, response, and recovery that local health departments engage in with community-based organizations, using a 15-item index for use by local health departments
Connectivity Measurement Tool[26]	Quantifies the level of connectivity of different organizations and systems involved in public health preparedness across 28 items
Preparedness Capacity Assessment Survey (PCAS) [27]	Creates an aggregate score summarizing preparedness of local health departments
Rapid Urban Health Security Assessment (RUHSA) [28]	Evaluates local-level health security capacities across 46 measures

The most prominent STLT preparedness tool we found in the literature is the NHSPI. First released in 2013 and updated annually using publicly available data, the NHSPI assesses U.S., state, and territorial health preparedness for a wide range of emergencies and disasters. Scores are disseminated publicly to inform planning efforts by internal and external stakeholders. In the literature, four peer-reviewed articles focused on the NHSPI, and nearly all articles that described U.S. preparedness tools mentioned the NHSPI as relevant background.[36,37,38,39] The NHSPI was developed with input and support from a variety of funders and partners, initially including the CDC and the Association of State and Territorial Health Officials, and beginning in 2016, the Robert Wood Johnson Foundation. The most recent edition of the NHSPI uses more than 60 publicly available data sources across 130 measures to create an overall preparedness score for each U.S. state on a scale of 1 to 10.[40] The tool also produces a score for each state across six domains: health security and surveillance; community planning and engagement; incident and information management; health care delivery; countermeasures management; and environmental and occupational health.

Existing tools contain a varying number of measures. Several of these tools are designed to measure preparedness broadly across 50 or more

Exhibit II.3. Prominent global tools to measure national public health and health care preparedness

Although this report focuses on U.S. tools to measure STLT preparedness, there are a variety of tools used globally to measure country-level preparedness. Prominent global preparedness tools include:

- **Oppenheim et al.'s Epidemic Preparedness Index.** Assesses national-level preparedness for infectious disease outbreaks.[29]
- **Global Health Security Index.** Assesses and benchmarks health security and related capabilities. This tool was originally developed in partnership among Nuclear Threat Initiative, Johns Hopkins Center for Health Security, and Economist Impact, with Brown University Pandemic Center supporting development of the most recent edition.[30]
- **Pan American Health Organization's Preparedness Index for Emergencies and Disasters.** Estimates the capacity of national health care systems to deal with and recover from emergencies and disasters.[31]
- **World Health Organization's Joint External Evaluation Tool.** Measures capacity and progress toward nine technical areas to assess a nation's capacity to prevent, detect, and rapidly respond to public health threats.[32]

As detailed in Appendix C, the COVID-19 pandemic exposed limitations in the predictive validity of many of these global tools.[33, 34, 35]

measures (such as the NHSPI, COPI, the HMSPI, RUHSA). Others have a narrower focus and fewer measures, such as the ADEPT, which contains 15 items focused specifically on local health departments' partnerships to prepare for, respond to, and recover from disasters, or the TFAH tool, which assesses preparedness across a focused set of 10 measures that are largely derived from the NHSPI.

In addition to the tools highlighted in Exhibit II.2, FEMA, CDC, and ASPR maintain lists of capabilities that are also intended to guide STLT public health preparedness. Although not intended to *quantify and summarize* preparedness like indices or measure sets, FEMA, CDC, and ASPR each maintain sets of capabilities and associated resources and trainings to guide STLT jurisdictions' efforts to prepare for and respond to emergencies. For example, FEMA maintains a list of 32 core capabilities that communities need to advance emergency preparedness.[41] CDC and ASPR maintain similar sets of capabilities and guidance for STLT public health agencies and health care coalitions,[IV] respectively.[42,43] Although these three sets of capabilities are intended for different users, contain different numbers of capabilities, and use different organizing domains to group the capabilities, all three are designed to be flexible and adaptable to meet the needs of all STLT jurisdictions, which vary in size, geography, and governance structures.[44,45,46] However, these capabilities sets are largely intended for self-administration and do not produce composite scores or other data sets that allow for quantitative comparison across jurisdictions. Exhibit II.4 highlights similarities and differences across these three capability sets.

Exhibit II.4. Characteristics of sets of capabilities from FEMA, CDC, and ASPR

Characteristic	FEMA's National Preparedness Goal Core Capabilities[41]	CDC's Public Health Emergency Preparedness and Response Capabilities[42]	ASPR's Health Care Preparedness and Response Capabilities[43]
Intended user or target audience	Whole communities	STLT jurisdictions and their public health agencies	Multisector health care coalitions, including health care organizations and public health agencies
Purpose	To assist everyone who has a role in preventing, protecting against, mitigating, responding to, and recovering from the threats and hazards that pose the greatest risk	To serve as national standards for STLT public health	Lists the necessary attributes for the health care system to save lives and continue to function in advance of, during, and after a response
Initial release year	2011	2011	2012
Most recent release year	2015	2018[a]	2017
Number of capabilities	32	15[a]	4[b]

[IV] Health care coalitions are defined as multisector groups of health care and response organizations—including public health agencies—within a geographic area.[46]

Characteristic	FEMA's National Preparedness Goal Core Capabilities[41]	CDC's Public Health Emergency Preparedness and Response Capabilities[42]	ASPR's Health Care Preparedness and Response Capabilities[43]
Domains	• Prevention • Protection • Mitigation • Response • Recovery	• Community resilience • Incident management • Information management • Countermeasures and mitigation • Surge management • Biosurveillance	• Foundation for health care and medical readiness • Health care and medical response coordination • Continuity of health care service delivery • Medical surge

[a] CDC launched the Next Generation of the Public Health Emergency Preparedness Program (PHEP) initiative in 2020, which may impact capability standards.

[b] ASPR expects to release an updated set of capabilities in 2024 that will add four new capabilities to the set (for a total of eight).

The COVID-19 pandemic exposed that preparedness tools—such as the NHSPI, TFAH tool, and other prominent global tools—were not accurate predictors of COVID-19 outcomes.[47,48,49,50] For example, the NHSPI did not successfully predict excess mortality rates at the outset of the COVID-19 pandemic even though the tool was assessed for construct validity during its development and continues to undergo validity and sensitivity testing on an ongoing basis as new sources of public health emergency data emerge. [51,52,53] Appendix C summarizes literature on preparedness tools' accuracy in predicting COVID-19 outcomes. Even before the COVID-19 pandemic, the evidence-base for preparedness tools was limited because the relative rarity of public health emergencies limited the use of real-world data to validate tools.[54]

2. Purpose and intended users

Five tools summarize preparedness for broad audiences, including internal and external stakeholders. The NHSPI, HMSPI, COPI, and TFAH tools all use publicly available data to generate results that are disseminated broadly and can be easily interpreted by a wide range of internal and external users. These users may include federal, state, and local officials; public health and health practitioners and administrators; multisector coalitions; researchers; communications specialists; and the general public.[55,56,57]. In addition, data from the HPP measure set are available for use by internal and external users. Although the HPP measure set is designed to be completed by HPP funding recipients and to inform federal program monitoring, data from the HPP measure set are publicly available in easy-to-use visualizations that show and compare how states and health care coalitions performed.[58]

Four tools are self-administered; they have a narrower focus and more targeted audience. The ADEPT, Connectivity Measurement Tool, PCAS, and RUHSA are self-guided tools that local jurisdictional leaders can use to assess preparedness and identify areas for improvement.[59,60,61] For example, the ADEPT tool collects data from local health department staff and their partners to measure the strength of local health departments' partnerships with community-based organizations to prepare for, respond to, and recover from emergencies.[62] Unlike the tools described above, results from the self-administered tools are intended for internal stakeholders only, and are not routinely shared with a broad audience.

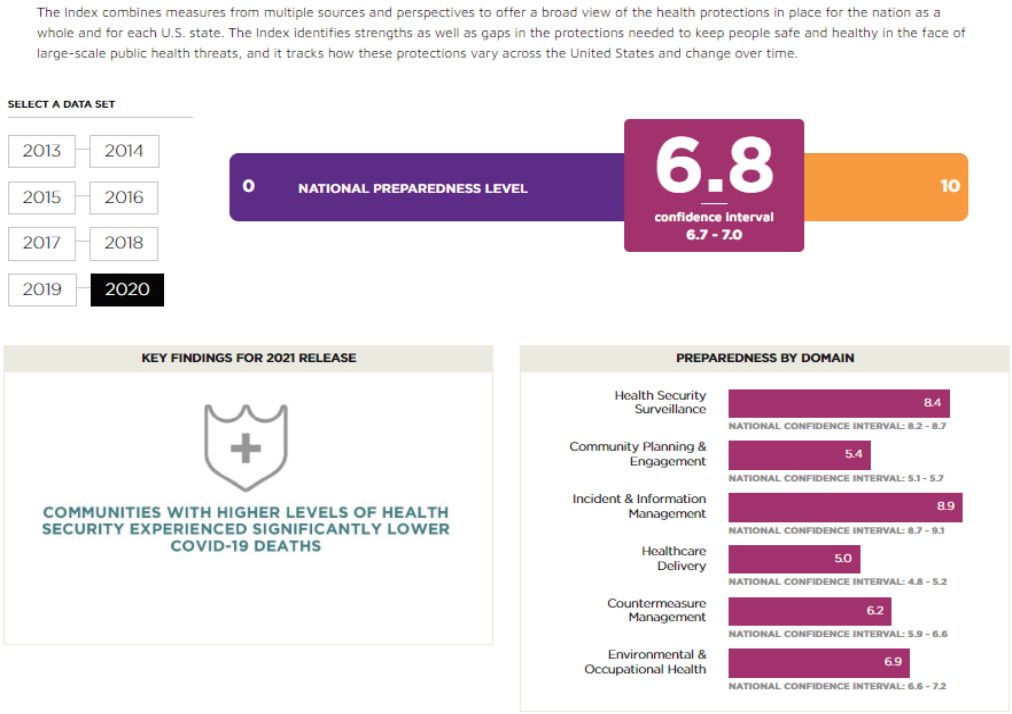
3. Jurisdiction levels

Two tools measure state and territorial preparedness, although additional tools produce results that can be aggregated at the state level. The NHSPI is a comprehensive tool to measure and summarize preparedness at the state and territorial levels. [63,] Similarly, the TFAH tool, which consist of nine measures from the NHSPI and an additional measure of state public health spending trends, provides another way for states to compare themselves to others and assess areas for improvement.[64] Further, some of the other tools that collect data within states, such as the HPP performance measure set, can be rolled up to the state level to understand preparedness across the state.

Seven tools assess preparedness at a local level—such as at the county, local health department, or hospital level—but they have noteworthy limitations that could be addressed through additional research and new or innovative sources of local data. For example, the COPI creates a composite outbreak preparedness score at the *county level* and assesses a wide range of measures across the emergency management cycle, but is a relatively new tool and consequently, has not been widely used or validated across settings.[65] Similarly, the HMSPI assesses preparedness at the *hospital level,* but the index has not been widely validated against hospital performance during actual disasters.[66]. The HPP measure set includes measures of preparedness for *health care coalitions*, but the size and composition of health care coalitions varies across localities, making the data difficult to compare. A few tools, such as the ADEPT, Connectivity Measurement Tool, PCAS, and RUHSA, measure the emergency preparedness of *local health departments*, but are self-assessment tools intended to be completed by staff at the public health departments and are not publicly reported (which would allow for comparison across local health departments). New or untapped sources of local data could support development of new tools that could facilitate comparison of local jurisdictions' preparedness and inform federal and STLT planning efforts.

Three of the STLT tools can assess preparedness at the national level. Results from two tools—the NHSPI and HPP measure set—are routinely aggregated at the national level to present a snapshot of national preparedness (an example from NHSPI is shown in Exhibit II.5). In addition, the TFAH tool groups states into tiers based on scores for each measure, which can be used to assess national preparedness, for example by assessing the number or percentage of states in the highest performing tier for each measure to assess relative strengths and weaknesses across the United States.

Exhibit II.5. Example of national preparedness data available on the NHSPI website



Note: The dashboard is available on the NHSPI website (https://nhspi.org/#by-state) and includes preparedness scores for the nation and by state, including the overall preparedness level and preparedness scores by domain.

4. How existing tools conceptualize preparedness

A few tools take a comprehensive approach to defining and measuring preparedness and include measures that address all five phases of emergency management. Comprehensive indices like the NHSPI and COPI include measures aligned with all five phases of the emergency management cycle (prevention, protection, mitigation, response, and recovery).[67,68] Tools with fewer measures and a narrower focus, such as the ADEPT or the HPP measure set, tend to focus on measuring jurisdictions' efforts to develop and implement emergency response plans related to prevention, mitigation, and response. Exhibit II.6 highlights examples of measures from select tools across the five phases of emergency management.

STLT preparedness tools include a mix of proactive and reactive measures. Proactive measures for disaster preparedness identify potential risks and establish best practices to mitigate their impact—aligning with the prevention, protection, and mitigation phases of emergency management—whereas reactive measures focus on post-event response and recovery.[69] The tools we found generally contain a mix of both types of measures. Examples of common proactive measures of preparedness include accreditation of public health and health care facilities, measures quantifying the size of vulnerable populations, such as children, adults ages 65 and older, or people eligible for Medicaid, and measures of social capital, such as housing affordability or voter turnout. The tools also contained numerous reactive measures focused on the ability to respond to threats, such as the number of burn care beds or emergency response teams, access to volunteers (measured as the number of registered Medical Reserve

Corp volunteers or the number of partnerships with volunteer entities), and availability of personal protective equipment, among others.

Exhibit II.6. Examples of measures that assess various aspects of the five phases of emergency management from select preparedness tools, including the NHSPI, COPI, HPP measure set, and ADEPT

Emergency management phase[a]	Examples of measures from select tools
Prevention. Ability to avoid, prevent, or stop imminent threats	• Number of epidemiologists per 100,000 population in the state, by quintile (NHSPI) • Population coverage for wastewater surveillance testing (COPI) • Percentage of health care coalitions engaged in their recipient's (state or large local health department's) jurisdiction risk assessment (HPP measure set) • State health department participates in a broad prevention collaborative addressing health care–associated infections (NHSPI)
Protection. Ability to secure the homeland against acts of terrorism and disasters	• Percentage of bridges that are in good or fair condition (transportation structural integrity) (NHSPI) • Number of infrastructure companies (e.g., utility and communications companies) and local public safety agencies (e.g., law enforcement) participating in the health care coalition (HPP measure set)
Mitigation. Ability to reduce loss of life and property by lessening the impact of disasters	• Number of obstetricians and gynecologists per 100,000 female population in the state (NHSPI) • Pediatric vaccination rate (defined as proportion of county's children with all required immunizations for school enrollment) (COPI) • Whether programs have conducted community outreach side-by-side with community-based organization staff to reach vulnerable and hard-to-reach populations (ADEPT) • Percentage of HCCs that access the de-identified emPOWER data map at least once every six months to identify the number of individuals with electricity-dependent medical and assistive equipment for planning purposes (HPP Measure Set)
Response. Ability to save lives, protect property and the environment, and meet basic humans needs after an incident	• State public health laboratory has a plan for a six-to-eight-week surge in testing capacity to respond to an outbreak or other public health event, with enough staffing capacity to work five 12-hour days for six to eight weeks in response to an infectious disease outbreak (NHSPI) • Number of community emergency response team (CERT) programs in a county per capita (COPI) • Program has coordinated the use of a community-based organization facility during a disaster (ADEPT) • Percentage of HCCs that have a complete and approved response plan annex addressing the specialty surge requirement (HPP measure set)
Recovery. Ability to help communities recover effectively	• Percentage of employed population in the state engaging in some work from home by telecommuting (NHPSI) • Quality of unemployment (UE) benefits (defined as ratio of state maximum weekly UE benefits divided by county's average supplemental poverty measure threshold) (COPI)

[a]Emergency management phases and definitions are from the FEMA National Preparedness Goal.[44]

ADEPT = Assessment for Disaster Engagement with Partners Tool; COPI = Community Outbreak Preparedness Index; HCC = health care coalition; NHSPI = National Health Security Preparedness Index; HPP = Hospital Preparedness Program.

Numerous tools measure specific aspects of preparedness, such as vulnerability or resiliency. Social vulnerability and community resilience play an important role in preparedness and are pertinent to health outcomes after emergencies and disasters.[78] To strengthen individual and community resilience in the U.S., HHS recently developed the Federal Plan for Equitable Long-Term Recovery and Resilience, which lays out an approach for federal agencies to cooperatively strengthen the vital conditions for health and well-being.[79] Although it is widely accepted that social vulnerability and resilience affect preparedness, there are competing views on the extent that these measures and other contextual factors should be included in preparedness tools. Some researchers believe these factors affect preparedness and so should be incorporated in indices,[80] but others suggest that preparedness indices should only measure factors within the immediate control of jurisdictions.[81] These tensions contribute to overarching challenges defining and conceptualizing preparedness. Although we do not focus on these tools in this chapter, Exhibit II.7 highlights several examples of tools that measure resilience and vulnerability.

Exhibit II.7. Examples of tools to measure health and social vulnerability or resilience[78]

- Baseline Resilience Indicators for Communities[70]
- Community Disaster Resilience Index[71]
- Community Resilience Estimates[72]
- Community Resilience Index[73]
- COVID-19 Community Vulnerability Index[74]
- COVID-19 Vulnerability Index[75]
- COVID-19 Pandemic Vulnerability Index[76]
- Social Vulnerability Index (SVI)[77]

5. Types of disasters addressed

Many tools take an "all-hazards" approach that measures preparedness for a range of disasters rather than for a specific type of disaster or emergency.[82] Eight of the nine tools take an all-hazards approach to measuring preparedness across emergency situations, including natural disasters; communicable disease outbreaks; cyberattacks; acts of terrorism; and risks related to chemical, biological, radiological, nuclear, and explosive incidents. Consequently, most measures within these tools are relevant to a range of disasters—for example, NHSPI's "percentage of local health departments in the state with an emergency preparedness coordinator" or TFAH's "change in state public health spending" measure—rather than targeting skills and resources needed by emergency type, such as whether a state has an evacuation route in place if a hurricane occurs.

The COPI is the only one of the nine tools we reviewed that focuses on preparedness for infectious disease outbreaks.[V] Before the COVID-19 pandemic, there were a few global tools—like the Epidemic Preparedness Index, Global Health Security Index, and Infectious Disease Vulnerability Index[87]— that assessed countries' preparedness to respond to infectious disease emergencies. A March 2023 study cited the need for additional measures to quantify preparedness and response capabilities for pandemics and infectious disease outbreaks specifically in the United States.[88] In response to the lack of local-level tools and COVID-19, a team at a California-based nonprofit developed the COPI to assess county-level preparedness across the five phases of emergency management for an outbreak of an infectious disease. The index measures strengths and gaps in areas such hospital surge capacity, nursing home staffing, insurance coverage and access to primary care, using over 30 data sources. It includes new data sources developed in response to COVID-19, such as the Centers for Medicare and Medicaid Services' Nursing Home COVID-19 Vaccination Data.

There are some efforts to measure components of STLT preparedness for natural disasters. Exhibit II.8 highlights examples of disaster-specific tools related to wildfire smoke exposure, hurricanes, tsunamis, and extreme heat. Although many of the factors assessed in these tools overlap with the all-hazards tools described above—such as measures of community socioeconomic status and unemployment— they also include factors that are specific to types of disasters. For example, the TsunamiReady guidelines include a measure of whether the community has produced tsunami evacuation maps, and the ReadyMapper data visualization tool, which has been used during wildfires and hurricanes, includes variables of population-level movement to show where people are evacuating from and where they are going.[89]

Exhibit II.8. Examples of tools that measure components of STLT preparedness for specific disasters

Examples of tools that measure components of STLT preparedness for specific disasters include:

- **Community Health Vulnerability Index.** Measures county-level vulnerability to wildfire smoke exposure. Health officials can use the tool in combination with air quality models to focus public health strategies on areas where air quality is impaired.[83]
- **ReadyMapper.** Tracks and measures response—including population mobility, infrastructure damage, and health system response capacity—during natural disasters. ReadyMapper was used during the wildfires in California and in the Hurricane Ida response in Louisiana.[84]
- **National Weather Service's TsunamiReady program and associated guidelines.** Establishes 16 guidelines for communities to work towards to mitigate, prepare for, and respond to tsunamis.[85]
- **Heat Vulnerability Index.** Assesses factors associated with adverse health effects during extreme heat to identify communities at the greatest risk and inform mitigation efforts, such as setting up cooling centers in vulnerable areas where many people do not have access to air conditioning.[86]

6. Data sources

Four tools leverage data from public sources, including national surveys, government agencies, and associations. The NHSPI, COPI, HMSPI, and TFAH tool all rely on publicly available data to inform measurement (Exhibit II.9). The NHSPI uses publicly available data from 64 sources to calculate states' preparedness scores,[90] and the COPI uses data from more than 30 sources.[91] A limitation

[V] As noted in Exhibit II.6, several tools specifically assess state and local vulnerability and resilience to COVID-19—and not other infectious diseases—but do not focus on preparedness.

to using publicly available data is that there are often lags in availability. For example, the latest NHSPI report, released in 2021, relies on data from 2020 and earlier, and the COPI report released in 2023 draws on some data sources dating back to 2014.

Five preparedness tools rely on self-reported data. The ADEPT, Connectivity Measurement Tool, PCAS, and RUHSA are self-assessment tools, meaning the data are collected and used by the jurisdiction only.[92,93,94,95,96,97] Although this approach expands the types of measures that can be assessed because tool developers are not limited by data availability, self-assessment tools do not allow for comparison across jurisdictions. Similarly, self-reported data are prone to response bias.[98] The HPP measure set is also self-reported by HPP funding recipients but results are disseminated publicly for external stakeholders.

Exhibit II.9. Examples of data sources used to measure preparedness in existing tools, by level (state and/or local) that the data are available

	State	Local
Survey data		
American Hospital Association Annual Survey	✓	✓
Association of Public Health Laboratories All-Hazards Laboratory Preparedness Survey	✓	
Association of Public Health Laboratories Comprehensive Laboratory Services	✓	
Association of State and Territorial Health Officials Profile Survey	✓	
Centers for Disease Control and Prevention's Behavioral Risk Factor Surveillance System	✓	✓
Centers for Disease Control and Prevention's Youth Risk Behavior Survey	✓	✓
Robert Wood Johnson Foundation's National Longitudinal Survey of Public Health Systems[a]	✓	✓
National Association of City and County Health Officials Profile of Local Health Departments		✓
U.S. Census Bureau's American Community Survey	✓	✓
U.S. Census Bureau's Current Population Survey	✓	
Publicly available data from government agencies		
Agency for Healthcare Research and Quality Pediatric Quality Indicators	✓	✓
Agency for Toxic Substance and Disease Registry Environmental Justice Index	✓	✓
Administration for Strategic Preparedness and Response Hospital Preparedness Program measure data	✓	✓
Administration for Strategic Preparedness and Response Medical Reserve Corp data	✓	
Bureau of Labor Statistics Occupational Employment Statistics	✓	✓
Centers for Disease Control and Prevention's National Snapshot of Public Health Preparedness	✓	
Centers for Disease Control and Prevention's National Health care Safety Network Prevention Status Reports	✓	
Centers for Disease Control and Prevention's Funding Recipient lists	✓	
CDC's National Vital Statistics System data	✓	
Centers for Medicare & Medicaid Services Hospital Compare	✓	✓
Centers for Medicare & Medicaid Skilled Nursing Facility Quality Reporting Program data	✓	✓
Federal Emergency Management Association Community Rating System	✓	✓

	State	Local
Health Resources and Services Administration data on health care shortage areas	✓	✓
National Plan & Provider Enumeration System National Provider Identifier registry	✓	✓
Data from associations and other organizations		
Association of Public Health Laboratories member list	✓	✓
Leapfrog group hospital safety score	✓	✓
NACCHO Project Public Health Ready participation		✓
National Emergency Management Association data	✓	
Penn State University Social Capital Index composite score of civic engagement		✓
Public Health Accreditation Board member list	✓	✓
United States Election Project General Election Turnout Rates	✓	

Note: Mathematica compiled the data sources in this table by reviewing the source lists for the NHSPI and HMSPI. The list focuses on publicly available data sources and is not meant to be exhaustive. We define local level data as any data available within states (such as data from a county, hospital system, health care coalition, or hospital). Survey data available at the local level may only be available for a sample of local jurisdictions.

[a] The survey was originally funded by the Centers for Disease Control and Prevention before the Robert Wood Johnson Foundation became the primary funder.

B. What are the gaps in existing public health and health care preparedness metrics?

In this section, we describe gaps in preparedness metrics, including gaps in:

- Factors that are measured in existing indices and measure sets
- Jurisdiction levels for which the preparedness tools are designed
- Types of disasters addressed
- Available data
- Other areas (including limitations)

1. Gaps in factors that are measured

Existing preparedness tools do not fully capture several important predictors of preparedness and response capacity. Next, we describe the predictors of preparedness that the literature and TEP cited as missing or insufficiently captured in preparedness measurement; they are also summarized in Exhibit II.10.

Exhibit II.10. Spotlight on the technical expert panel: Factors that are inadequately captured in existing metrics

Technical expert panel (TEP) members highlighted several important factors that affect preparedness in the U.S., but are inadequately captured in existing preparedness indices and tools:

- Partnerships and cross-sector collaboration (mentioned 11 times by TEP members)
- Individual training and preparedness (mentioned 11 times by TEP members)
- Administrative capacity to hire and scale up operations (mentioned seven times by TEP members)
- Political factors (mentioned six times by TEP members)
- Social vulnerability (mentioned six times by TEP members)
- Public trust (mentioned five times by TEP members)

Source: Mathematica's analysis of TEP data.

Current preparedness tools do not adequately assess partnerships and cross-sector collaboration. It is well documented that cross-sector collaboration between public health, health systems, community-based organizations, laboratories, and

other organizations is critical for promoting resource sharing and engaging communities and volunteers in preparedness, response, and recovery.[99,100,101,102] However, both the literature and the TEP emphasized the need for better measures of cross-sector collaboration; in fact, this was one of the most prominent TEP themes. [103] A TEP member noted that it can be resource intensive to collect the survey data needed to assess relational coordination.

> *"Being able to measure relational coordination and connectivity is something we did learn from the COVID-19 pandemic. That is a measure that is really important [for preparedness]."*
>
> — TEP member

We can see these weaknesses when we examine specific tools. For example, the NHSPI has a sub-domain dedicated to "cross-sector/community collaboration" that includes six measures, but these measures (which rely on publicly available data) do not capture the extent to which a state and its localities have plans and systems in place to collaborate during emergencies.[VI] Likewise, a known weakness of the HMSPI is that it includes publicly available measures of individual hospitals' preparedness for mass casualty events, but it does not measure the synergies between hospitals that would improve collective response.[104] On the other hand, the HPP performance measure set is specifically designed to collect and summarize information about cross-sector health care coalitions and the extent to which their member organizations partner with each other.[105] However, HPP funding recipients cite challenges with burdensome reporting requirements.[106]

Existing metrics fail to consider whether the individuals working in public health and health organizations are adequately trained to perform their duties. TEP members highlighted that numerous tools measure the number and types of staff in an organization, but do not assess how they have been trained and whether that training gives them the ability to effectively respond to an emergency. TEP members pointed out that ill-prepared leadership across sectors and a lack of real-world experience among epidemiologists and other experts are both key limitations of existing metrics. The CDC's guidance document summarizing public health capabilities includes detailed suggestions on individual skills and training needs to meet the required capabilities,[107] which implies that STLT public health agencies may have this information to guide their planning, but it is not currently assessed in indices and measure sets.

> *'What we're finding now is that [key questions are,] "Can you move people, money, stuff, and data around quickly? Do you have the systems and authorities in place to allow you to do that? Can you hire quickly? Can you buy things quickly?"'*
>
> — TEP member

TEP members highlighted the need for additional measures to assess STLT health departments' administrative capacity to hire staff and scale up operations during emergencies. TEP members noted that a variety of metrics are designed to measure epidemiological or public health laboratory capacity (for example, number of epidemiologists per 100,000), but fewer measures examine functions like human resources and procurement (for example, staff who

[VI] Examples of measures in this NHSPI domain include "state health department accredited by the Public Health Accreditation Board" and "percent of hospitals in the state that participate in health care preparedness coalitions through the Hospital Preparedness Program." See NHSPI 2020 Measure Set.

support recruitment, training, payroll and benefit administration, and purchasing). The COVID-19 pandemic exposed how critical such measures are, as many STLT public health departments struggled to quickly hire staff and source computers and other basic supplies for contact tracing operations and COVID-19 testing sites.[108]

Preparedness indices do not capture the importance of political factors in public health preparedness and response outcomes. Existing tools do not measure the presence of effective political leadership[109,110] or how political leanings might affect public health operations and outcomes.[111] Several TEP members expanded on this, noting that measuring the presence of a public health emergency response plan, as many existing indices do, is not sufficient when political leaders have the power to prevent these plans from being executed.

> *"You can have capacity, you can have the capability, and people could be robustly prepared … but if the political will isn't there, [it's not] going to happen."*
>
> — TEP member

Existing metrics do not adequately measure STLT jurisdictions' preparedness to mitigate, respond to, and recover from emergencies affecting socially and medically vulnerable populations. Most of the comprehensive preparedness indices that we focused on for this report attempt to assess risks for some vulnerable populations, but also exclude important subgroups. For example, the NHSPI has a sub-domain on "at-risk populations." The four measures in the domain focus on children and people who are pregnant, but do not measure other important groups that may be at elevated risk of experiencing adverse effects from disasters, such as people living with disabilities or people who are uninsured. On the other hand, indices focused exclusively on vulnerability (such as those in Exhibit II.7) may help to identify communities that may need support before, during, or after disasters based on socioeconomic factors, household characteristics, racial and ethnic composition, and housing types and transportation, but they miss other critical factors related to preparedness, such as emergency planning and surge capacity. Several TEP members reinforced this finding, emphasizing the importance of identifying communities that are most vulnerable to disasters and the extent that these communities are receiving the support they need to prevent, mitigate, respond to, and recover from emergencies. The literature highlighted opportunities to combine social vulnerability data from tools like CDC's Social Vulnerability Index with results from preparedness tools to improve the predictive capability of existing preparedness tools for underserved communities.[112,113]

TEP members highlighted a need for measures of public trust in government. Public trust in the government had important implications for population-level health behaviors and outcomes during the COVID-19 pandemic.[114] TEP members noted that this factor is not adequately addressed in existing preparedness measures and should be explored. A starting point could be examining existing metrics that quantify public trust in government (Exhibit II.11).

2. Gaps by jurisdiction type

Currently, there is no comprehensive all-hazards index to measure and guide local jurisdictions' emergency preparedness efforts. Although there are a handful of tools to measure preparedness across localities within states (for example, at the county or local health department level), none of these tools comprehensively quantify local public health preparedness across disaster types. Existing tools at the local

level either have a somewhat narrow focus, such as the ADEPT tool's focus on partnerships for preparedness and response, or HMSPI's focus on hospital surge plans and capacity, or are intended for self-administration rather than broader dissemination, such as the PCAS and RUHSA. Further, although the recently developed COPI takes a comprehensive approach to assessing preparedness for infectious disease outbreak at the county level, its focus on infectious disease and lack of widespread validation may limit its usefulness on a broad scale.

This is a critical gap that makes it challenging for federal and state officials to understand which communities and local public health departments are less prepared and need additional resources and support to address emergencies. The TEP mentioned this gap, noting that the lack of a local all-hazards index makes it challenging for similarly sized communities to compare themselves to each other and prioritize areas for improvement. However, there are trade-offs to consider. One TEP member cautioned that all-hazards indices at the local level may be challenging for localities to use and interpret, given the notable variation in size, geographic characteristics, and governance structure across local jurisdictions. This TEP member suggested that hazard-specific tools may be easier for local jurisdictions to use. Another TEP member cautioned that STLT jurisdictions may fear political consequences and the stigma of "being at the bottom of the list" if they have a low preparedness score. Because local organizations such as public health agencies, hospitals, and other health care and social service providers are on the front lines of emergency responses, it is important to consider options for developing additional tools to understand community-level preparedness.[119]

Exhibit II.11. Examples of metrics that quantify public trust in government

Several *indices* quantify public trust in government across multiple dimensions. For example:

- **The Citizen Trust in Government Organizations scale** includes nine items measuring citizens' perception of government agencies' competence, benevolence, and integrity.[115]
- **The Trust in Government Measure** quantifies public trust as it relates to population health interventions and public health messaging. The tool includes 17 items related to perceptions of the government's capability, effectiveness, judgement, beneficence, and integrity.[116]

In addition, a few U.S. organizations collect and track standalone *measures* of citizens' self-reported trust in government. For example:

- **Pew Research Center** estimates the percentage of people in the U.S. who trust the government to do what is right "just about always", "most of the time", "only some of the time" or "never" based on polling data.[117,]
- **A survey conducted by the Harvard T. H. Chan School of Public Health** asks respondents to rate their level of trust in federal, state, and local public health agencies using a four-point Likert scale. [118]

Tribal communities need tailored metrics to help them assess preparedness and response. FEMA's pre-disaster recovery guide for tribal governments highlights the need for special considerations for tribal communities when planning for emergencies.[120] For example, the guide encourages tribal communities to consider the presence of sacred or historic land when taking inventory of assets during emergency preparedness exercises, and emphasizes the criticality of cross-jurisdictional coordination (including intergovernmental agreements with state, local, and other tribal governments) given the sovereignty of federally recognized tribes. Yet the existing preparedness tools and the related literature do not discuss implications or use of measurement tools with or by tribal organizations, suggesting that potential gaps may exist in measuring preparedness within tribal nations and communities. More recently, FEMA released the 2022–2026

National Tribal Strategy, which expands on the FEMA national preparedness goal by addressing its responsibilities to tribal nations.[121] One aim of the National Tribal Strategy is to develop tribal-specific technical assistance resources and case studies to help Tribal Nations reach goals related to preparedness, protection, mitigation, response, and recovery. Although metrics could help set and track progress toward these goals, it will be critical that any tools to assess the preparedness of tribal groups are developed in close consultation with tribes and do not have any unexpected consequences.

3. Gaps by disaster type

Most preparedness tools discussed here were designed to assess "all hazards" preparedness, which may not reliably predict outcomes for all types of emergencies. The literature and TEP members highlighted that all-hazards indices do not reliably predict outcomes for all types of emergencies and may be challenging for jurisdictional users to use to improve preparedness.[122] This was evidenced during the COVID-19 pandemic, when numerous studies found that all-hazards indices were poor predictors of COVID-19 mortality rates. (See Appendix C.)[123,124,125] TEP members highlighted unique challenges in measuring preparedness for infectious disease outbreaks—borne out by the experience of the COVID-19 pandemic—such as the need to plan for a sustained response over many months or years, reduction in routine program functions, changing priorities and policies, and the critical role of public health leaders relative to other common types of responders, such as fire and rescue. These challenges also apply to measuring preparedness for other emergency situations, such as concurrent disasters (e.g., a hurricane occurring during an infectious disease outbreak) or cascading hazards (e.g., a tsunami triggering electrical grid failure that ultimately results in a nuclear power plant incident).

There are potential gaps in preparedness metrics for emergent threats, such as cybersecurity threats, natural disasters, and other hazards. Infectious disease outbreaks are not the only type of hazard that require specialized plans. Cybersecurity threats require extensive planning that may not be captured in all-hazards indices. For example, the NHSPI assesses the existence of data systems to coordinate emergency response, but does not measure plans if these data systems are breached or inoperable due to cybersecurity attacks.[127] A 2023 report released by the White House highlighted the need for a national cybersecurity strategy, including approaches to measure preparedness for cybersecurity threats.[128] Similarly, natural disasters have unique preparedness needs. For example, planning for storms and floods involves determining evacuation routes, planning to protect food and water from contamination, and developing communication plans to update the public during power outages.[129] With the growing threat of cyber-related service disruptions and natural disasters and

Exhibit II.12. Local health departments' perception of preparedness by threat

The 2022 NACCHO Survey of Local Health Department Preparedness asks respondents to assess their own preparedness and concern for 23 different threats/hazards.[126] Among the 23 hazards, there are seven hazards on which their concern was substantially higher than they thought their preparedness was (defined as a difference of 20 percentage points [ppts] or more):

- Opioid abuse and overdose (58 ppt difference)
- Medical supply chain disruptions (38 ppt difference)
- Cyber-related threats (35 ppt difference)
- Active shooter (24 ppt difference)
- Critical infrastructure protection (24 ppt difference)
- Storms/ flooding (23 ppt difference)
- Vaccine-preventable diseases (23 ppt difference)

rising concerns about the hazards listed in Exhibit II.12, it is important to ensure there are ways to adequately measure STLT preparedness for these types of events.[130,131]

4. Gaps in available data

There are gaps in data sources used to measure preparedness at the local level. Many data sources are only available for public use at the state or national level (Exhibit II.9), and only about half of these data sources are available at the sub-state level. The literature attributes the lack of comprehensive indices at the local level, in part, to the lack of standardized data collection among local public health agencies,[132,133] as well as challenges related to interoperability (for example, incompatible software and systems, diverse data sources, STLT-level regulations around data sharing, and concerns about data security and privacy) and the lack of a public health IT infrastructure network.[134]

Data are not always timely. Several TEP members mentioned that static measures of preparedness can be misleading because they only capture a single point in time and are not regularly updated. This is especially true of assessing measures of response capacity such as vacant hospital beds or availability of personal protective equipment. Many data sources like national surveys tend to be collected sporadically and may have lags between the times when data are collected and when they are publicly available. There is a growing need to identify data sources that are frequently updated and rapidly available for public use so more timely measures of preparedness are available.

> *"Static measures [of preparedness] give us a lot of misleading information about what capacity we do or do not have."*
>
> — TEP member

5. Other gaps and limitations

The scan highlighted a few additional limitations in STLT jurisdictions' ability to use existing preparedness tools, such as challenges adapting scores from indices to their local contexts and using the tools for goal setting. This suggests that there is a need for greater STLT engagement in developing and refining metrics, and in informing development of technical assistance tools to support use and interpretation of metrics. A few TEP members said it can be difficult for STLT jurisdictions to interpret and adapt preparedness scores from existing indices to their unique context to identify the greatest threats and risks their own community faces. Furthermore, for both state and local jurisdictions, preparedness tools lack benchmarks to help guide goal setting and improvement. Although indices like the NHSPI contain helpful information to summarize preparedness, the literature cites challenges at the STLT level in *using* this information to set goals and guide improvement.[135] Moving forward, those responsible for developing and improving metrics should consider ways to continuously engage STLT jurisdictions and their partners in developing, testing, and refining tools. This would increase awareness of tools and ensure they are actionable for end users.[136,137,138]

C. What lessons learned from the COVID-19 pandemic can inform measurement of emergency preparedness and response at STLT public health agencies in the future?

Experiences from the COVID-19 pandemic offer critical takeaways that can inform the development of more robust and effective measures in the future. Below, we highlight some of these lessons learned.

The COVID-19 pandemic exposed preparedness tools' lack of predictive validity. As noted in section II.1 and described in detail in Appendix C, numerous studies found that preparedness tools—including the NHSPI, TFAH tool, and prominent all-hazards global tools—were poor predictors of COVID-19 mortality rates.[139,140,141] This underscores the need to explore ways to improve measurement within existing tools and consider whether all-hazards tools are the best way to assess preparedness for the wide range of unique emergencies that the country is likely to face. It also highlights the need to test and refine existing tools on an ongoing basis as new sources of public health emergency data become available.

During the pandemic, researchers uncovered a variety of factors associated with public health outcomes that should be considered and measured when assessing emergency preparedness. As highlighted in Section II.B, factors such as strength of partnerships, political will, public trust, and social vulnerability were shown to be associated with key outcomes during the pandemic, and TEP members underscored them as noteworthy gaps in existing metrics. We can improve our understanding of preparedness by finding ways to measure these factors. Relatedly, a few TEP members noted that there is potential to use artificial intelligence to expedite review of after-action reports and qualitative data on preparedness to discover additional factors to measure.

The COVID-19 pandemic underscored the need to embed equity into emergency preparedness and response systems, and thus, into how we measure communities' preparedness and assess their vulnerabilities. It is well documented that the COVID-19 pandemic disproportionately impacted historically marginalized communities.[142,143] For example, one study showed that communities with higher rates of social and health vulnerability had significantly lower health security levels as measured by the NHSPI.[144] This underscores the need for emergency preparedness systems to adopt approaches that promote equitable crisis response processes and outcomes. Examples of equitable approaches to crisis response include creating diverse crisis response teams and partnering with community organizations known to local communities, who can help build trust and support communication with groups at elevated risk of poor health outcomes due to structural and systemic barriers. The CDC recently implemented the Public Health Response Readiness Framework, which includes health equity as one 10 program priorities. The 2024-2028 PHEP notice of funding opportunity (NOFO) embeds health equity requirements in the NOFO's three overarching strategies.[145]However, there remains a need to develop equity-focused preparedness metrics that align with the changes to the CDC framework and incorporate them in existing indices and tools to quantify inequities in preparedness. This need is further articulated in a 2023 report from the American Medical Association, which calls for improved collection of demographic and social needs data (such as race and ethnicity, language, disability status, and gender identity) to reliably detect, measure, and evaluate inequities in crisis preparedness and response.[146]

Investments in data infrastructure could improve measurement of preparedness, especially at the local level where measurement is limited by a lack of standardized data sources. The COVID-19

pandemic exposed many weaknesses in the public health data and surveillance infrastructure in the United States, including limitations in reporting and tracking lab test results, lack of interoperability across health care and public health reporting systems, and gaps in the types of data that are collected and tracked, among others.[147,148] Improved data infrastructure, sharing, and collection was mentioned nearly 20 times by members of the expert panel. This is especially true at the local level, where lack of timely, standardized data (along with other factors such as limited resources, local priorities, and so on) makes it challenging to create composite measures of preparedness. CDC's multibillion dollar Data Modernization Initiative, which began in 2020, aims to improve data infrastructure to make it easier for STLT public health agencies to report data (including data related to preparedness) and for state and federal officials to use these data to inform decision making. TEP members noted that better data infrastructure—including systems that are updated with data in real time—could help the nation transition from point-in-time measurement of preparedness to continuous assessment, which would be a significant advance. To support data infrastructure improvements, many TEP members highlighted that federal and STLT public health agencies need additional funding and other resources so they can invest in new data systems and support ongoing changes to the ones they have.

Although existing metrics have been updated and improved substantially in the last decade, the evidence base for public health and health care preparedness metrics remains weak, and substantial work remains at all levels—national, state, local, tribal territorial, and the private sector—to ensure the United States is prepared to respond to federal public health and health care emergencies.[149] Although the development of tools like the NHSPI, TFAH tool, COPI, and others listed in Appendix B has advanced STLT preparedness measurement, noteworthy gaps remain in public health preparedness metrics and in STLT emergency preparedness more broadly. For example, a 2023 Government Accountability Office (GAO) report stated that substantial deficits in the federal government's preparedness for emergencies remain—noting that GAO had made 155 recommendations to HHS for improvements in the prior ten years, and only 64 had been implemented. In the wake of the COVID-19 pandemic, the literature also highlights the need for improvements to other aspects of the U.S. public health infrastructure—such as building the public health workforce, advancing the collection and use of public health data, and enhancing communication from public health agencies to the communities they serve—to enhance preparedness for future emergencies.[150] Improving tools to measure public health preparedness is key to tracking the nation's progress towards emergency preparedness goals, but the lack of consensus on how preparedness should be conceptualized and defined in preparedness frameworks, capabilities lists, and tools complicates the path to success in this area. Looking forward, it will be important to know which strategies can address the gaps in preparedness metrics so the federal government and STLT public health agencies can find the weaknesses and better allocate resources to improve emergency preparedness nationwide.

III. Strategies to Improve Measurement of Public Health and Health Care Preparedness

Gaps and challenges in current preparedness metrics can inform refinement of domestic preparedness metrics going forward. Considering takeaways from Chapter II, this chapter focuses on ways to improve preparedness measurement by addressing the following two research questions:

1. What key attributes should public health and health care preparedness measures and indices have, and what gaps from Chapter II do these attributes address?
2. What strategies should potentially be explored to improve measurement of public health and health care preparedness?

A. What key attributes should new public health and health care preparedness measures have, and what gaps would they address?

To identify strategies for improving preparedness measurement, researchers and policymakers should begin by (1) examining the ideal attributes of measures and indices, and (2) considering how they could fill the gaps revealed here. Defining key attributes or necessary characteristics of metrics provides a set of criteria to assess measures and indices against. Exhibit III.1 lists 10 key attributes to consider for preparedness metrics, along with the gaps they address. This list is based on the attributes put forth by Lichiello and Turnock in their *Guidebook for Performance Measurement*.[151] The research team then drew on existing literature on public health measurement to consider modifications to the attributes. These 10 attributes were ultimately organized into three categories:

- *Research-dependent* attributes—including importance, validity, and reliability—require quantitative analysis to understand whether the measure or index is relevant, accurate, and repeatable.
- *Data-source dependent* attributes—including availability, responsiveness, and completeness—concern access to timely data sources that underlie measures and indices.
- *Ready for real-world use* attributes—including understandability, actionability, credibility, and flexibility/adaptability—support a measure or index's ability to be used in practice.

Eight of the attributes highlighted in Exhibit III.1 apply to both the measures themselves and to indices; two of the attributes—*completeness* and *flexibility and adaptability*—apply solely to indices. Lichiello and Turnock noted that there is a risk to complete and accurate reporting if there will be negative consequences for staff or organizations that report low scores. Lichiello and Turnock described this as a need for "abuse-proof" measurement,[152] while the TEP noted a need to avoid political leaders fearing retribution over low scores.

Exhibit III.1. Key attributes of preparedness measures and the gaps they address[a]

No.	Attribute	Description and risk if not met	Current gaps or weaknesses addressed
Research-dependent			
1	Importance	Reflects a structure, process, or outcome with a large impact on health; demonstrates substantial variation reflecting meaningful underlying differences;[153] is directly related to objectives. **Risk if not met:** The measure or index may not focus on activities that preserve life or improve health or other key outcomes following an emergency.	**Metrics reflect a wide range of competing capabilities and frameworks** set forth by federal agencies and researchers, with little evidence base for selection of their components.
2	Validity	Captures the essence of what it purports to measure, instead of correlated characteristics. **Risk if not met:** The measure or index may inaccurately indicate a jurisdiction is prepared, when in reality it is not.	**High performance on preparedness metrics did not predict COVID-19 outcomes** for many indices; there is a **lack of evidence** supporting the validity of measures in practice.
3	Reliability	Has a high likelihood of yielding the same results in repeated trials, so there are low levels of random error in measurement. **Risk if not met:** The measure or index may accurately predict preparedness in one scenario, but not others.	There is a **lack of evidence** supporting the reliability of measures and indices in practice.
Data source-dependent			
4	Availability	Readily available with means on hand; accessible, ongoing sources of data.[154] **Risk if not met:** The measure or index will require time-intensive data collection and reporting, displacing focus that could be spent on preparedness activities.	**Data limitations** have hindered development of comprehensive local indices. Lack of data makes it difficult to measure some aspects of preparedness, such as the strength of partnerships. Challenges with interoperability impede timely data sharing, a critical component of preparedness.
5	Responsiveness	Able to detect change; properly calibrated and sensitive enough to pick up important changes.[155] **Risk if not met:** The measure or index is not up to date when an incident occurs; that is, a capacity that appeared adequate from older data is not there.	**Gaps in timely data sources and lack of dynamic measures of preparedness** limit existing indices' ability to register critical changes in preparedness.
6	Completeness[b]	An emergency preparedness index should ideally cover *all* important aspects of emergency preparedness that affect outcomes. **Risk if not met:** The index will fail to predict the quality of response and outcomes in an emergency. For example, if the index captures a wide range of factors that affect preparedness but does not include measures of surge capacity, a jurisdiction may be ill-equipped to meet demand for health services, leading to increased preventable mortality following a disaster.	**Existing metrics fail to consider the wide range of factors that affect preparedness**, such as the strength of partnerships, individual training, and administrative capabilities. **There is a lack of equity-focused preparedness metrics** to identify potential inequities in crisis preparedness and response.

No.	Attribute	Description and risk if not met	Current gaps or weaknesses addressed
Ready for real-world use			
7	Understandability	Easily understood by all, with minimal explanation. **Risk if not met:** The measure or index is unlikely to be used in practice or could be used incorrectly.	**All-hazards indices and tools that compound preparedness scores across a range of measures may be difficult to interpret**, especially at the local level, and there are few hazard-specific preparedness tools available at the STLT level.
8	Actionability	Process or condition within the organization's control.[156] **Risk if not met:** The measure or index is unlikely to improve readiness or be used in practice.	**Many indices lack benchmarks** to help jurisdictions set goals, track progress, and take action to improve preparedness. **The lack of regularly updated data sources** makes it challenging to measure factors that change quickly, limiting the actionability of preparedness measures that rely on outdated data.
9	Credibility	Supported by stakeholders. **Risk if not met:** The measure or index is unlikely to be used in practice.	STLT jurisdictions have described challenges using existing tools, which may be related to **lack of engagement of STLT jurisdictions** in the development and refinement of metrics.
10	Flexibility and adaptability[b]	An index should be adaptable across jurisdiction types. For example, an index may need to have required and optional components that could be tailored to a jurisdiction and its specific hazards.[157,158] **Risk if not met:** The index will not accurately capture preparedness across communities with different risks and/or may not be feasibly used across communities with different public health structures.	There is a **lack of metrics that can be adapted to the unique needs and risks** of STLT jurisdictions in a way that informs their efforts to improve preparedness.

[a]Attributes 1–5, 7, and 9 are adapted from Lichiello and Turnock's *Guidebook for Performance Measurement*;[146] additional references are as noted.

[b]Attributes 6 and 10 apply to indices only.

The COVID-19 experience suggests that federal, state, local, and nongovernmental organizations could establish priorities for preparedness measurement—including assessing tradeoffs between measure attributes and the feasibility of various measurement strategies—to make incremental progress as resources become available. One of the TEP members lamented the lack of progress in the past decade on improving availability of preparedness measurement metrics. A variety of factors have limited progress, including constrained resources and the challenge of prioritizing how to invest them. More recently, fading memories of just how ill-prepared the U.S. was during the COVID-19 public health emergency could also be a factor. To help ASPE and others capitalize on ASPE's investment in this project,

in the next section we outline a series of strategies, along with their likely resource intensity, for consideration to help build forward momentum on preparedness measurement activities.

B. What strategies could potentially be explored to improve measurement of public health and health care preparedness?

Given the challenges discussed, there is an opportunity to pursue development of improved measures and indices that have the attributes described above in Exhibit III.1 and that address the gaps in metrics described in Chapter II. This section describes four strategies to advance preparedness measurement (Exhibit III.2).

Exhibit III.2. Four strategies that could potentially advance preparedness measurement

1. **Address gaps in existing metrics** by developing or refining important measures of preparedness and supplementing preparedness metrics with contextual data.
2. **Improve how health equity is addressed in preparedness metrics** by engaging underserved communities in continuous efforts to advance measurement and considering social vulnerability data together with preparedness measures.
3. **Improve source data and use additional analysis** to enhance the availability, responsiveness, and salience of preparedness metrics.
4. **Enhance actionability and understandability of metrics** by developing and disseminating information on exemplars.

For each of the four proposed strategies, we present tables that outline potential action steps that could support achievement of these strategies (Exhibits III.5, III.6, III.9, and III.10). For each action step, we also estimate its resource intensity—low, medium, or high—to shed light on strategy feasibility. Low-intensity strategies are those likely to require one to three staff working for less than a year; high-intensity strategies are those that involve large-scale data collections or system changes; and medium-intensity strategies capture efforts likely to fall between the low- and high-intensity ranges. Some of the medium- and high-intensity strategies would benefit from building on the results of listed low-intensity strategies, while others—those we have italicized—could begin as soon as resources are available.

Strategy #1: Address gaps in existing metrics by developing or refining important measures of preparedness and supplementing preparedness metrics with contextual data.

Developing new measures for critical aspects of preparedness would help fill identified gaps in current measures and improve current measurement tools. As shown in Exhibit III.1, a key attribute of a desirable measure is a proven link between the activity and outcomes. Further, indices should incorporate *all important aspects* of emergency preparedness to achieve *completeness*. As discussed during the TEP, several factors that contribute to preparedness are missing from current measures and indices. Important preparedness factors that could be considered in future measure development work include individual preparedness, cross-sector partnerships, and administrative response capabilities, each discussed further below, with examples for potential follow up actions listed in Exhibit III.5. We also discuss the importance of pairing supplemental data on social, political, economic, and environmental factors with preparedness metrics, acknowledging that data sources to measure these factors are not

currently available on an ongoing basis, meaning the cost of collecting these data would need to be weighed against the importance of these measures.

- ***Individual readiness of the public health and health care workforce.*** As highlighted in Chapter II, TEP members noted the importance of measuring *individual readiness*—that is, whether public health and health care workers have the right training to respond to public health emergencies—in addition to organizational preparedness. In practice, this may be easier said than done. For example, during the COVID-19 public health emergency, guidance for managing the response was sometimes emerging locally and disparately, due to the novel situation, and there were limited and sometimes lagged or incomplete data to inform that guidance. While neither individual nor organizational preparedness training plans can account for all possible emergency scenarios with challenging conditions like the COVID-19 pandemic, a better-trained workforce might mitigate some future challenges. To the extent that policymakers need to issue local guidance as with COVID-19, they should also consider what supplemental training or mentorship may be needed for health care workers to effectively implement their guidance.

  Beyond individual training, some degree of cross-training might also improve preparedness, since during the COVID-19 public health emergency, many public health and health care professionals had to assume roles for which they were not trained.[162] Although there are many options for training public health and health care workers and leaders on emergency readiness,[163,164] the literature did not describe any metrics that report the percentage of the public health or health care workforce that have recently completed relevant, evidence-based training. Learning management systems, which are widely available online, can easily collect and report the kinds of data that could be useful, such as the specific roles of those trained (leader, health care worker, and so on), when they had their last training, percentage of employees trained, and so on.[165] In conjunction with measuring individual readiness, there may be an opportunity to improve or expand existing preparedness programs and clarify a minimum training expectation to ensure that all the types of professionals necessary for an effective response are trained.

- ***Cross-sector partnerships.*** As noted in Chapter II, partnerships between public health, health care, and other sectors such as community-based organizations are critical to emergency response. To better understand the strength of a jurisdiction's partnerships, a standardized survey approach that preserves anonymity of respondents could objectively capture this information. Some survey tools exist to measure partnerships (Exhibit III.3). Going forward, work could focus on reviewing existing tools and considering whether they could be adapted for

Exhibit III.3. Survey instruments to measure the strength of partnerships among STLT public health departments and their partners

- **The ADEPT index** is intended for use by local health departments to assess engagement with cross-sector partners; however, it does not capture other partners' perspectives on the relationships.[159]
- **A survey tool to measure post-disaster resilience** was developed and administered to 369 community-based organizations in New York, as well as the New York State Department of Health and Hygiene to measure partnership activity and resilience after Hurricane Sandy, but was not intended to assess preparedness broadly.[160]
- **The Connectivity Measurement Tool** includes a survey of multiple partners in public health emergency response about their perceived connectivity, but there is little research on the validity of the tool in peer-reviewed research.[161]

widespread use, and on exploring the feasibility of incorporating a survey-based measure of partnership strength into routine local preparedness measurement.

- ***Administrative response capability.*** To improve measurement of administrative capabilities like hiring or procurement at STLT health departments, there may be an opportunity to build on existing data collection efforts. For example, NACCHO's 2022 Preparedness Profile survey asked a sample of local health departments whether the following set of administrative capabilities were in place: (1) ability to receive and use emergency funding, (2) ability to reduce time to contract for or procure necessary goods and services, (3) ability to allocate or reallocate financial resources to pay for staff during an emergency, and (4) ability to reduce time required to hire staff or reassign existing staff.[166] Between 23 and 37 percent of local health departments reported these capabilities were either not in place, or they were unsure if they were in place. The NACCHO tool is a valuable resource; further development of administrative capacity measures using NACCHO's tool or something similar could enhance understanding of administrative capability trends across communities and over time.[VII]

- ***Contextual factors affecting response and outcomes.*** Numerous social, political, economic, and environmental factors affect emergency response and outcomes but are outside the control of the public health and health care sector (Exhibit III.4). Incorporating measurement of these factors into public health preparedness indices would fail to consider the key measure attribute of "actionability." Instead, routinely measuring and analyzing these contextual factors, and presenting them alongside preparedness measures within the control of the public health and health care sector, could help policymakers and the public understand areas for investment.[VIII]

Exhibit III.4. Contextual factors affecting public health preparedness and response outcomes

- Social and health vulnerability[167]
- Political will[168]
- Public trust[169]
- Policies/laws/regulations[170,171]
- Supply chain[172]
- Funding for public health[173]
- Built and natural environment context[174,175,176]

Exhibit III.5. Potential approaches to address strategy #1, and likely resource intensity of each

Examples of potential follow-up approaches	Likely resource intensity
• **Advance individual training and measurement of training through professional associations.** Conduct key informant interviews with key public health and health professional associations about interest in encouraging members to take a standardized emergency preparedness training and any outstanding needs or barriers to doing that; identify how progress could be made and measured (could lead to need for a Medium or High resource intensity follow-up to support the associations).	Low

[VII] If a survey were expanded and implemented annually, there could be an opportunity to improve actionability: the same NACCHO survey identified barriers to administrative preparedness. Connecting health departments with resources to improve readiness based on barriers identified during the survey process would help make the measures actionable.

[VIII] A TEP member especially advocated for shining a light on government laws, policies, and regulations, providing an example of how a hiring freeze had prevented jurisdictions from hiring during COVID-19 despite the availability of federal funding to do so.

Examples of potential follow-up approaches	Likely resource intensity
• **Evaluate existing online preparedness curricula to begin setting a foundation for measurement of individual preparedness.** Evaluate existing online curricula and obtain target audience input to suggest improvements to help optimize them. • **Explore degree program accreditation as a tool to improve readiness of future public health professionals and set a foundation for a national measure of individual preparedness.** Meet with the Council on Education for Public Health, which accredits schools' public health degree programs, to explore potential and any initiatives underway to increase "on-the-ground" training to 100 percent of students, and any initiatives promoting cross-training.	
• **Develop new trainings to fill gaps to support improvement on future measurement of individual preparedness.** Conduct a gap analysis and fill gaps in existing emergency preparedness curricula by developing new modules or trainings. • ***Advance measurement of strength of essential partnerships.*** Review existing tools for measuring strength of partnerships as they relate to emergency preparedness, obtain input from the field, suggest possible adaptations needed for widespread use, and explore the feasibility of incorporating a survey-based measure into routine local preparedness measurement efforts. • ***Investigate contextual factors critical to response and outcomes.*** Develop a method to quantify or assess contextual factors affecting emergency response and outcomes based on publicly available data sources; develop options for presenting these along with preparedness indices and gather target audience feedback on best way to consider these alongside preparedness.	Medium
• ***Improve measurement of administrative response capability and provide support to help STLT jurisdictions overcome barriers.*** Expand NACCHO or similar survey effort to capture administrative response capability across *all* local health departments, and survey them annually until they are all consistently reporting these capabilities. This effort should be paired with resources, including technical assistance, to overcome barriers to improving these capabilities. • ***Develop a national-level measure or measures corresponding to administrative response capability.*** Track progress toward having 100 percent of new graduates in key fields enter the professional workforce with appropriate preparedness training.	High

Notes: *Low-intensity*=likely to require one to three staff working for less than a year; *high-intensity*=those that involve large-scale data collections or system changes; *medium-intensity*=efforts likely to fall between the low- and high-intensity ranges. Low-intensity and italicized efforts could begin when resources are available. Italicized efforts are not dependent on low-intensity efforts to be completed first. Medium- and high-intensity efforts not italicized would best be structured using results from the low-intensity efforts listed.

Strategy #2: Improve how health equity is addressed in preparedness metrics by engaging underserved communities in continuous efforts to advance measurement and considering social vulnerability data together with preparedness measures.

Incorporating health equity into preparedness measurement could be considered high priority and would strengthen the credibility and importance of existing metrics. The TEP emphasized the importance of health equity, citing literature on the disproportionate burden of COVID-19 disease and death on socially and medically vulnerable populations.[177] In addition, addressing health equity in preparedness measurement aligns with new priorities identified by the COVID-19 Health Equity Task Force[IX] and with CDC's efforts to incorporate health equity into the Public Health Response Readiness

[IX] The Task Force was created through E.O. 13995 to make recommendations to the president for mitigating health inequities caused or exacerbated by the pandemic, and for preventing them in the future (Office of Minority Health.

Framework.[178] PHEP requires its funding recipients to report on functional exercises involving critical workforce groups and disproportionately impacted populations. However, there are no current measures or indices that quantify preparedness to serve socially and medically vulnerable populations, such as those disproportionately impacted by COVID-19.

One way to approach the challenge of incorporating health equity into preparedness measurement is for researchers to engage frontline response staff at public health and health care organizations in identifying local needs for metrics and ways to capture the required data. Historically, measure development has relied on input from academic experts, as opposed to feedback from real-world, frontline response workers embedded in the communities where emergencies occur. Future measure development could prioritize community input and buy-in to ensure that measures are (1) feasible—that is, they will work given local circumstances; (2) credible, because they are informed by users themselves; and (3) important, because they are connected to desired outcomes based on end-user experiences.[X] Local public health workers could be engaged along with first responders and emergency management personnel in developing hazard-specific metrics tailored to their communities, which were identified in the literature as missing from the "all-hazards approach" that most national frameworks and STLT tools take. Exhibit III.6 highlights an example of health equity in local preparedness metrics.

Exhibit III.6. Example of health equity in local hazard-specific preparedness metrics:

A jurisdiction may have a neighborhood with low average household income and a high percentage of people of color, and that neighborhood may also be physically low-lying or in a floodplain and as such, more at-risk for severe flooding. Because this neighborhood has specific needs that the rest of the jurisdiction does not, input from local responders, local public health workers, and community members could be convened to identify or create a preparedness metric to address their needs.

Explore optimal ways to communicate preparedness metrics alongside measures of social vulnerability to guide equitable allocation of resources. A community's social and health vulnerability is highly correlated with emergency response and recovery outcomes regardless of the level of preparedness.[179] Pairing social and health vulnerability information together with preparedness measures or indices could increase awareness of communities with low preparedness and particularly high vulnerability so policymakers could allocate resources effectively. This approach would require developing and testing a preferred format for communicating social vulnerability and preparedness measures together.

Examples of potential follow-up approaches are summarized in Exhibit III.7.

"COVID-19 Health Equity Task Force – Charter." U.S. Department of Health and Human Services, January 2021. https://www.minorityhealth.hhs.gov/omh/browse.aspx?lvl=3&lvlid=118. OMH, 2022).

[X] The NHSPI included a stakeholder engagement and communications workgroup in 2017; however, the workgroup does not appear active today.

Exhibit III.7. Potential approaches to address strategy #2 and likely resource intensity of each

Examples of potential follow-up approaches	Likely resource intensity
• **Develop recommendations for an effective approach to present social and health vulnerability indicators with or within preparedness indices.** Mockup multiple options for displaying social and health vulnerability indicators together with preparedness indices and obtain feedback from target audiences to iterate to an effective approach or visualization method. Promote the visualization tool in conjunction with the release of indices.	Low
• ***Identify locally appropriate metrics focused on health equity to advance equity-focused preparedness measurement in communities.*** Select communities based on social vulnerability that are part of larger, less vulnerable cities or counties that are typically the unit for measurement. Engage front-line response staff to explore what metrics, including hazard-specific metrics, would capture emergency preparedness and how these metrics could be included for visibility as the larger area is assessed.	Medium to high, depending on number of communities included

Notes: *Low-intensity*=likely to require one to three staff working for less than a year; *high-intensity*=those that involve large-scale data collections or system changes; *medium-intensity*=efforts likely to fall between the low- and high-intensity ranges. Low-intensity and italicized efforts could begin when resources are available. Italicized efforts are not dependent on low-intensity efforts being completed first. Medium- and high-intensity efforts not italicized would best be structured using results from the low-intensity efforts listed.

Strategy #3: Improve source data and use additional analysis to enhance the availability, responsiveness, and salience of preparedness metrics.

Underused data sources—such as after-action reports and non-public data—as well as unconventional data sources, such as cell phone data, could help close gaps in data availability, particularly at the local level. Improving use of underused data is an appealing approach as it avoids burden from new data collection, but it presents other challenges that vary by data source. Below we highlight specific considerations for each potential data source; Exhibit III.10 provides a set of potential follow-up approaches to consider.

/ ***After-action reports (AARs).*** AARs are a promising data source for identifying factors that affect preparedness (Exhibit III.8)[181,182] However, communities are not required to complete them after disasters, and there is no standardized format.[183,184] While a standardized format would better facilitate cross-AAR analysis, an analysis identified strong AARs using varied methodologies and following different outlines,[185] suggesting that imposing a single format may sacrifice utility for the localities that need the results. Another possibility is requiring a standardized metadata template, including categories summarizing frequent types of challenges and recommended improvements, as a way to facilitate cross-AAR analysis and learning without sacrificing flexibility.

Exhibit III.8. What is an after-action report?

As defined by FEMA, "An after-action report is developed after exercises and real-world incidents to summarize key information and continuous improvement-related analytical findings, including observations and recommended actions. It is a detailed and comprehensive document that describes what went well and what did not go well, considers why, and provides recommended actions."[180]

A concern raised by the TEP members is that AARs may be seen as perfunctory requirements and not as tools to inform future preparedness. One TEP member suggested future research could analyze AARs

from different communities and disaster types, comparing findings to existing metrics and revising metrics to address challenges. Small-scale qualitative analysis of AARs has been conducted before[186] and could be scaled up by using artificial intelligence to find patterns in reported processes and challenges. The availability of AARs would need to be explored; one data source could be the Homeland Security Digital Library, which houses an archive of AARs from jurisdictions across the United States, some of which are available publicly. The variable quality of the AARs will affect the usefulness of these data; improvements such as peer review of draft AARs could increase the value of AARs for both learning and improvement.[187]

- ***Non-public data sources.*** Non-public data sources, such as health system data, could build an evidence base for the importance of measures. The environmental scan and TEP identified several non-public data sources that could help measure factors related to preparedness or link preparedness metrics to outcomes (Exhibit III.9). These data sources are restricted, so efforts to link measures and outcomes using this data would require data sharing agreements, de-identification, and other data security protocols.

Exhibit III.9. Examples of non-public data sources that could be leveraged to improve measurement of preparedness

- Non-public HPP data, such as data from the Real-World Incident Reporting and Evaluation Tool, and performance measure data.[188]
- Emergency management data maintained by vendors, cited by a TEP member as a central source of granular data from large numbers of hospitals on operations, capacity, and incidents.
- Data from large hospital systems; for example, a TEP member shared that one system's readiness project includes 140 preparedness-related data points for more than 100 hospitals.

- ***Unconventional data collection and sources.*** The COVID-19 pandemic required creative approaches to obtaining urgently needed data. For example, surge periods during the pandemic required first responders to access hospital capacity data such as beds and key equipment available on a near real-time basis. To address this gap, the CDC's National Healthcare Safety Network[XI] (NHSN) provided a repository for hospitals (or state intermediaries) to frequently input important facility-level data. In addition, some states implemented their own statewide systems to share these data, such as New York's publicly accessible Hospital Bed Capacity Dashboard.[XII] Beyond facility-level preparedness data, a TEP member noted that many jurisdictions turned to nontraditional data such as cell phone data to track cases and social media data to track masking trends. Despite the critical information this type of infrastructure can convey, collecting these data can be burdensome and may be considered intrusive, so future efforts may need to explore making these data available solely during emergencies, rather than making them continuously available (as in the case of cell phone data).

[XI] The CDC's NHSN is the nation's most widely used health care-associated infection tracking system, with most hospitals in the U.S. contributing data through a secure, web-based application, traditionally on a monthly or quarterly basis. https://www.cdc.gov/nhsn/index.html.

[XII] Bed occupancy data were required to input data on hospital and ICU beds available Monday through Friday on the State's Electronic Response Data System; see https://coronavirus.health.ny.gov/hospital-bed-capacity.

Exhibit III.10. Potential approaches to address strategy #3, and likely resource-intensity of each

Examples of potential follow-up approaches	Likely resource intensity
• **Explore feasibility of use of AI with AARs.** Test feasibility of using AI methods, including machine learning, to efficiently identify patterns in the challenges and learnings reported in AARs that could have implications for preparedness metrics. • **Explore stakeholder receptiveness to implementing a metadata template for AARs**, and develop one if they are receptive, along with options for housing and accessing metadata. Could lead to a medium resource intensity project to build and encourage use of a new system. • **Explore feasibility and benefits of using non-public data sources** such as those in Exhibit III.8 to advance the evidence base for preparedness metrics. • **Capture lessons learned from use of cell phone data and social media tracking during COVID-19.** Explore how similar or improved use of these sources can be ready for future emergencies.	Low
• **Analyze AARs on a large scale,** to identify themes in response experience; reflect and report on the themes as they relate to current measurement and related needs; conduct follow up interviews to verify themes and identify any additional reflections. • ***Facilitate improvement of AARs' quality and availability,*** through peer review and support to ensure AARs are created and shared following all disasters. • **Undertake research using non-public data sources** such as those in Exhibit III.8 to advance the evidence base for preparedness metrics, once feasibility and a strong plan have been established.	Medium
• ***Identify and develop automated data solutions that would reduce reporting burden, such as helping hospitals establish interfaces*** to automate NHSN submissions to obtain real-time, local data for key capacity measures.	High

Notes: *Low-intensity*=likely to require one to three staff working for less than a year; *high-intensity*=those that involve large-scale data collections or system changes; *medium-intensity*=efforts likely to fall between the low- and high-intensity ranges.

Low-intensity and italicized efforts could begin when resources are available. Italicized efforts are not dependent on low-intensity efforts to be completed first. Medium- and high-intensity efforts not italicized would best be structured using results from the low-intensity efforts listed.

Strategy #4: Enhance actionability and understandability of metrics by developing and disseminating information on exemplars.

All-hazards preparedness indices may seem overwhelming to public health leaders given the extensive capabilities they measure, the distinct local contexts and risks to consider, and the complexity of cross-sector partnerships that are required. Presenting leaders with real-life examples of exemplary emergency response can highlight the feasibility of "getting it right." For example, one TEP member noted, and another agreed, that it is important to showcase examples from hospitals or health systems that performed relatively well—across both health outcomes and financially—during the COVID-19 pandemic to encourage health systems to invest in preparedness. ASPR's Healthcare Emergency Preparedness Information Gateway (known as ASPR TRACIE) provides examples of strong community-level responses, but more can be done to improve access to and use of exemplar cases. Exhibit III.11 presents examples of potential action items for consideration.

Exhibit III.11. Potential approaches to address strategy #4, and likely resource-intensity of each

Examples of potential follow-up approaches	Likely resource intensity
• **Conduct a needs assessment to identify jurisdiction types, organizations, and disaster types most in need of exemplar models, and a landscape assessment to identify existing strong examples and find important gaps.** Explore the key audience need through a small set of interviews to ensure subsequent case studies (a medium resource intensity approach) are designed to meet the needs.	Low
• **Develop case studies to fill identified needs** for exemplar models and disseminate them to relevant audiences.	Medium

Notes: *Low-intensity*=likely to require one to three staff working for less than a year; *high-intensity*=those that involve large-scale data collections or system changes; *medium-intensity*=efforts likely to fall between the low- and high-intensity ranges.

C. Discussion

The four strategies shared in this section offer potential directions for the future to address clear measurement gaps discussed in Chapter II. Ultimately, the availability of better tools to measure and understand gaps in preparedness against specific threats could inform federal and state resource allocation and help set priorities to improve preparedness of public health and healthcare system for the next public health threat. In the hands of dedicated leadership, better measurement can also catalyze and enable improvement, leading to a better-prepared nation.

Progress will depend on the interest and resources from government and nongovernment organizations leading the way in preparedness at all jurisdiction levels. Each involved organization—at the federal level to include ASPR, CDC, and FEMA—has its own preexisting priorities, and preparedness measurement improvement resources will inevitably compete with program support. The breadth of the suggested improvements should not discourage incremental enhancements. Incremental enhancements, such as any handful of the low- and medium-intensity efforts described above, especially if coordinated across organizations, could translate to a markedly better understanding of the status of preparedness among public health leaders, policymakers, and the general public, thanks to better measurement. The specific approaches that should be undertaken first depend, as a practical matter, on how managers within the relevant agencies find the efforts well-matched with existing work, resources, and program opportunities.

References

[1] Nelson, C., N. Lurie, J. Wasserman, and S. Zakowski. "Conceptualizing and Defining Public Health Emergency Preparedness." *American Journal of Public Health,* vol. 97, April 1, 2007, pp. S9–S11. https://doi.org/10.2105/AJPH.2007.114496.

[2] Administration for Strategic Preparedness and Response. "ASPR TRACIE Evaluation of Hazard Vulnerability Assessment Tools." January 2024. https://files.asprtracie.hhs.gov/documents/aspr-tracie-evaluation-of-hva-tools-3-10-17.pdf. Accessed May 6, 2024.

[3] Federal Emergency Management Agency. "Mission Areas and Core Capabilities." July 2020. https://www.fema.gov/emergency-managers/national-preparedness/mission-core-capabilities. Accessed June 17, 2024.

[4] Federal Emergency Management Agency. "National Preparedness Goal." March 2023. https://www.fema.gov/emergency-managers/national-preparedness/goal. Accessed May 6, 2024.

[5] Assistant Secretary for Preparedness and Response. "Hospital Preparedness Program." n.d. https://aspr.hhs.gov/HealthCareReadiness/HPP/Documents/HPP%20Fact%20Sheet%20April%202021.pdf. Accessed May 6, 2024.

[6] Centers for Disease Control and Prevention. "2023 Readiness Report." 2023. https://www.cdc.gov/orr/media/pdfs/ORR_2023_Readiness_Report_508.pdf. Accessed June 17, 2024.

[7] Federal Emergency Management Agency. "Preparedness Grants." February 2024. https://www.fema.gov/grants/preparedness. Accessed June 17, 2024.

[8] World Health Organization. "Key Approaches to Strengthening Emergency Preparedness and Response." n.d. https://www.who.int/europe/emergencies/our-work-in-emergencies/key-approaches. Accessed June 17, 2024.

[9] Federal Emergency Management Agency. "2019 National Threat and Hazard Identification and Risk Assessment (THIRA): Overview and Methodology." U.S. Department of Homeland Security, July 2019. https://www.fema.gov/sites/default/files/2020-06/fema_national-thira-overview-methodology_2019_0.pdf. Accessed May 6, 2024.

[10] Centers for Disease Control and Prevention. "Division of State and Local Readiness Friday Update." June 2024. https://www.cdc.gov/readiness/media/pdfs/2024/06/2024-06-07_DSLR-Friday-Update_508C.pdf.

[11] Centers for Medicare & Medicaid Services. "Core EP Rule Elements." September 2023. https://www.cms.gov/medicare/health-safety-standards/quality-safety-oversight-emergency-preparedness/core-ep-rule-elements. Accessed June 13, 2024.

[12] Centers for Disease Control and Prevention. "Public Health Emergency Preparedness and Response Capabilities: National Standards for State, Local, Tribal, and Territorial Public Health." October 2018. https://www.cdc.gov/readiness/media/pdfs/CDC_PreparednesResponseCapabilities_October2018_Final_508.pdf.

[13] Administration for Strategic Preparedness and Response. "General Overview of Healthcare Coalitions." n.d. https://files.asprtracie.hhs.gov/documents/aspr-tracie-general-overview-hccs.pdf.

[14] Stoto, M., and C. Nelson. "Measuring and Assessing Public Health Emergency Preparedness: A Methodological Primer." *SSRN*, September 2012. https://doi.org/10.2139/ssrn.2886349.

[15] Asch, S.M., M. Stoto, M. Mendes, R. Burciaga Valdez, M.E. Gallagher, P. Halverson, and N. Lurie. "A Review of Instruments Assessing Public Health Preparedness." *Public Health Reports*, vol. 120, no. 5, October 2005, pp. 532–542. https://doi.org/10.1177/003335490512000508.

[16] Nelson, C., N. Lurie, J. Wasserman, and S. Zakowski. "Conceptualizing and Defining Public Health Emergency Preparedness." *American Journal of Public Health,* vol. 97, April 1, 2007, pp. S9–S11. https://doi.org/10.2105/AJPH.2007.114496.

[17] Stoto, M., and C. Nelson. "Measuring and Assessing Public Health Emergency Preparedness: A Methodological Primer." *SSRN*, August 2023. http://dx.doi.org/10.2139/ssrn.4538548.

[18] Ibid.

[19] Piltch-Loeb, R.N., C. Nelson, J. Kraemer, E. Savoia, and M. Stoto. "A Peer Assessment Approach for Learning from Public Health Emergencies." *Public Health Reports*, vol. 129, no. 6, November 2014, pp. 28–34. https://doi.org/10.1177/00333549141296S405.

[20] Ghosh, J.K., B. Martinez, C. Beck, and C. Rogers. "Community Outbreak Preparedness Index (COPI)." Heluna Health, October 2023. COPI_Technical_Report_October_2023.pdf.

[21] Marcozzi, D.E., R. Pietrobon, J.V. Lawler, M.T. French, C. Mecher, J. Peffer, N.E. Baehr, et al. "Development of a Hospital Medical Surge Preparedness Index Using a National Hospital Survey." *Health Service and Outcomes Research Methodology*, vol. 20, no. 1, 2020, pp. 60–83.

[22] Administration for Strategic Preparedness and Response. "2019–2023 Hospital Preparedness Program: Performance Measures Implementation Guidance." 2022. https://aspr.hhs.gov/HealthCareReadiness/guidance/Documents/2019-2023-HPP-Performance-Measures-Implementation-Guidance-8Nov22.pdf.

[23] Lumpkin, J.R., Y.K. Miller, T. Inglesby, J.M. Links, A.T. Schwartz, C.C. Slemp, R.L. Burhans, J. Blumenstock, and A.S. Khan. "The Importance of Establishing a National Health Security Preparedness Index." *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science,* vol. 11, no. 1, 2013, pp. 81–87.

[24] McKillop, M., R. Faberman, and D. Alpert Lieberman. "Ready or Not 2024: Protecting the Public's Health from Diseases, Disasters, and Bioterrorism." Trust for America's Health, 2024. https://www.tfah.org/report-details/ready-or-not-2024/.

[25] Glik, D.C., D.P. Eisenman, I. Donatello, A. Afifi, M. Stajura, M.L. Prelip, J. Sammartinova, et al. "Reliability and Validity of the Assessment for Disaster Engagement with Partners Tool (ADEPT) for Local Health Departments." *Public Health Reports*, vol. 129, no. 6, suppl. 4, 2014, pp. 77–86. https://doi.org/10.1177/00333549141296S411.

[26] Dorn, B.C., E. Savoia, M.A. Testa, M.A. Stoto, and L.J. Marcus. "Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance." *Public Health Reports,* vol. 122, no. 3, 2007, pp. 329-38. doi: 10.1177/003335490712200306. PMID: 17518304; PMCID: PMC1847495. Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance - PMC (nih.gov).

[27] Davis, Mary, Glen Mays, James Bellamy, Christine Bevc, and Cammie Marti. "Improving Public Health Preparedness Capacity Measurement: Development of the Local Health Department Preparedness Capacities Assessment Survey." *Disaster Medicine and Public Health Preparedness*, vol 7, 2013, pp. 1–7. 10.1017/dmp.2013.108.

[28] Boyce, M.R., and R. Katz. "Rapid Urban Health Security Assessment Tool: A New Resource for Evaluating Local-Level Public Health Preparedness." *BMJ Global Health*, vol. 5, no. 6, 2020, article e002606.

[29] Oppenheim, B., M. Gallivan, N.K. Madhav, N. Brown, V. Serhiyenko, N.D. Wolfe, and P. Ayscue. "Assessing Global Preparedness for the Next Pandemic: Development and Application of an Epidemic Preparedness Index." *BMJ Global Health*, vol. 4, no. 1, 2019, article e001157.

[30] Global Health Security Index. "What is the GHS Index?" n.d. https://ghsindex.org/about/#:~:text=The%20Global%20Health%20Security%20%28GHS%29%20Index%20is%20an,prevent%2C%20detect%2C%20and%20respond%20to%20epidemics%20and%20pandemics.

[31] Pan American Health Organization. "Preparedness Index for Health Emergencies and Disasters." 2019. https://www.paho.org/en/documents/preparedness-index-health-emergencies-and-disasters-0.

[32] Gupta, V., J.D. Kraemer, R. Katz, A.K. Jha, V.B. Kerry, J. Sane, J. Ollgren, et al. "Analysis of Results from the Joint External Evaluation: Examining Its Strength and Assessing for Trends Among Participating Countries." *Journal of Global Health*, vol. 8, no. 2, 2018.

[33] Stribling, J., A. Clifton, G. McGill, and K. de Vries. "Examining the UK Covid-19 Mortality Paradox: Pandemic Preparedness, Healthcare Expenditure, and the Nursing Workforce." Journal of Advanced Nursing, vol. 76, no. 12, 2020, pp. 3218–3227. https://doi.org/10.1111/jan.14562.

[34] Kaiser, M.A., T.Y. Chen, and P. Gluckman. "Should Policy Makers Trust Composite Indices? A Commentary on the Pitfalls of Inappropriate Indices for Policy Formation." Health Research Policy and Systems, vol. 19, no.1, March 2021. https://doi.org10.1186/s12961-021-00702-4.

[35] Haider, N., A. Yavlinsky, Y.M. Chang, M.N. Hasan, C. Benfield, A.Y. Osman, M.J. Uddin, et al. "The Global Health Security Index and Joint External Evaluation Score for Health Preparedness Are Not Correlated with Countries' COVID-19 Detection Response Time and Mortality Outcome." Epidemiology and Infection, vol. 148, 2020, article e210. https://doi.org/10.1017/S0950268820002046.

[36] Lumpkin, J.R., Y.K. Miller, T. Inglesby, J.M. Links, A.T. Schwartz, C.C. Slemp, R.L. Burhans, J. Blumenstock, and A.S. Khan. "The Importance of Establishing a National Health Security Preparedness Index." *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science,* vol. 11, no. 1, 2013, pp. 81–87.

[37] Keim, M.E., and A.P. Lovallo. "Validity of the National Health Security Preparedness Index as a Predictor of Excess COVID-19 Mortality." *Prehospital and Disaster Medicine*, vol. 36, no. 2, 2021, pp. 141–144. https://doi.org/10.1017/S1049023X20001521.

[38] Moulton, A.D. "A COVID-19 Lesson: Better Health Emergency Preparedness Standards Are Needed." *Health Security*, vol. 20, no. 6, 2022, pp. 457–466. https://doi.org/10.1089/hs.2022.0037.

[39] Mays, G., and M. Childress. "2021 Release of National Health Security Preparedness Index." University of Colorado, Colorado School of Public Health, June 2021.

[40] National Health Security Preparedness Index. "Measures List: National Health Security Preparedness Index, 2021 Release." https://nhspi.org/wp-content/uploads/2021/06/2021-NHSPI-Measure-List.pdf.

[41] Federal Emergency Management Agency. "National Preparedness Goal." U.S. Department of Homeland Security, September 2015. https://www.fema.gov/sites/default/files/2020-06/national_preparedness_goal_2nd_edition.pdf.

[42] Centers for Disease Control and Prevention. "Public Health Emergency Preparedness and Response Capabilities: National Standards for State, Local, Tribal, and Territorial Public Health." October 2018. https://www.cdc.gov/orr/readiness/00_docs/CDC_PreparednesResponseCapabilities_October2018_Final_508.pdf.

[43] Assistant Secretary for Preparedness and Response. "2017–2022 Health Care Preparedness and Response Capabilities." November 2016. https://www.phe.gov/Preparedness/planning/hpp/reports/Documents/2017-2022-healthcare-pr-capablities.pdf.

[44] Federal Emergency Management Agency. "National Preparedness Goal." U.S. Department of Homeland Security, September 2015. https://www.fema.gov/sites/default/files/2020-06/national_preparedness_goal_2nd_edition.pdf.

[45] Centers for Disease Control and Prevention. "Public Health Emergency Preparedness and Response Capabilities: National Standards for State, Local, Tribal, and Territorial Public Health." October 2018. https://www.cdc.gov/orr/readiness/00_docs/CDC_PreparednesResponseCapabilities_October2018_Final_508.pdf.

[46] Assistant Secretary for Preparedness and Response. "2017–2022 Health Care Preparedness and Response Capabilities." November 2016. https://www.phe.gov/Preparedness/planning/hpp/reports/Documents/2017-2022-healthcare-pr-capablities.pdf.

[47] Stribling, J., A. Clifton, G. McGill, and K. de Vries. "Examining the UK Covid-19 Mortality Paradox: Pandemic Preparedness, Healthcare Expenditure, and the Nursing Workforce." *Journal of Advanced Nursing*, vol. 76, no. 12, 2020, pp. 3218–3227. https://doi.org/10.1111/jan.14562.

[48] Kaiser, M.A., T.Y. Chen, and P. Gluckman. "Should Policy Makers Trust Composite Indices? A Commentary on the Pitfalls of Inappropriate Indices for Policy Formation." *Health Research Policy and Systems*, vol. 19, no.1, March 2021. https://doi.org10.1186/s12961-021-00702-4.

[49] Keim, M.E., and A.P. Lovallo. "Validity of the National Health Security Preparedness Index as a Predictor of Excess COVID-19 Mortality." *Prehospital and Disaster Medicine*, vol. 36, no. 2, 2021, pp. 141–144. https://doi.org/10.1017/S1049023X20001521.

[50] Haider, N., A. Yavlinsky, Y.M. Chang, M.N. Hasan, C. Benfield, A.Y. Osman, M.J. Uddin, et al. "The Global Health Security Index and Joint External Evaluation Score for Health Preparedness Are Not Correlated with Countries' COVID-19 Detection Response Time and Mortality Outcome." *Epidemiology and Infection*, vol. 148, 2020, article e210. https://doi.org/10.1017/S0950268820002046.

[51] Keim, M.E., and A.P. Lovallo. "Validity of the National Health Security Preparedness Index as a Predictor of Excess COVID-19 Mortality." *Prehospital and Disaster Medicine*, vol. 36, no. 2, 2021, pp. 141–144. https://doi.org/10.1017/S1049023X20001521.

[52] Moulton, A.D. "A COVID-19 Lesson: Better Health Emergency Preparedness Standards Are Needed." *Health Security*, vol. 20, no. 6, 2022, pp. 457–466. https://doi.org/10.1089/hs.2022.0037.

[53] Mays, G., and M. Childress. "2021 Release of National Health Security Preparedness Index." University of Colorado, Colorado School of Public Health, June 2021.

[54] Nelson, C., N. Lurie, J. Wasserman. "Assessing public health emergency preparedness: concepts, tools, and challenges." *Annual Rev. Public Health*, vol. 28, 2007, pp. 1- 18. https://doi.org/10.1146/annurev.publhealth.28.021406.144054.

[55] National Health Security Preparedness Index. "Measures List: National Health Security Preparedness Index, 2021 Release" 2021. https://nhspi.org/wp-content/uploads/2021/06/2021-NHSPI-Measure-List.pdf.

[56] McKillop, M., R. Faberman, and D. Alpert Lieberman. "Ready or Not 2024: Protecting the Public's Health from Diseases, Disasters, and Bioterrorism." Trust for America's Health, 2024. https://www.tfah.org/report-details/ready-or-not-2024/.

[57] Ghosh, J.K., B. Martinez, C. Beck, and C. Rogers. "Community Outbreak Preparedness Index (COPI)." Heluna Health, October 2023. COPI_Technical_Report_October_2023.pdf.

[58] U.S. Department of Health and Human Services. "HPP Performance Metrics – FY 2021 Dashboard." 2021. https://dhhs.maps.arcgis.com/apps/dashboards/71b5f53173cb4f4e9248b85244158151.

[59] Dorn, B.C., E. Savoia, M.A. Testa, M.A. Stoto, and L.J. Marcus. "Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance." *Public Health Reports,* vol. 122, no. 3, 2007, pp. 329-38. doi: 10.1177/003335490712200306. PMID: 17518304; PMCID: PMC1847495. Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance - PMC (nih.gov).

[60] Davis, Mary, Glen Mays, James Bellamy, Christine Bevc, and Cammie Marti. "Improving Public Health Preparedness Capacity Measurement: Development of the Local Health Department Preparedness Capacities Assessment Survey." *Disaster Medicine and Public Health Preparedness*, vol 7, 2013, pp. 1–7. 10.1017/dmp.2013.108.

[61] Boyce, M.R., and R. Katz. "Rapid Urban Health Security Assessment Tool: A New Resource for Evaluating Local-Level Public Health Preparedness." *BMJ Global Health*, vol. 5, no. 6, 2020, article e002606.

[62] Glik, D.C., D.P. Eisenman, I. Donatello, A. Afifi, M. Stajura, M.L. Prelip, J. Sammartinova, et al. "Reliability and Validity of the Assessment for Disaster Engagement with Partners Tool (ADEPT) for Local Health Departments." *Public Health Reports*, vol. 129, no. 6, suppl. 4, 2014, pp. 77–86. https://doi.org/10.1177/00333549141296S411.

[63] National Health Security Preparedness Index. "Methodology for the 2021 Release of the National Health Security Preparedness Index." https://nhspi.org/wp-content/uploads/2021/NHSPI_2021_Methodology.pdf.

[64] McKillop, M., R. Faberman, and D. Alpert Lieberman. "Ready or Not 2024: Protecting the Public's Health from Diseases, Disasters, and Bioterrorism." Trust for America's Health, 2024. https://www.tfah.org/report-details/ready-or-not-2024/.

[65] Ghosh, J.K., B. Martinez, C. Beck, and C. Rogers. "Community Outbreak Preparedness Index (COPI)." Heluna Health, October 2023. COPI_Technical_Report_October_2023.pdf.

[66] Marcozzi, D.E., R. Pietrobon, J.V. Lawler, M.T. French, C. Mecher, J. Peffer, N.E. Baehr, et al. "Development of a Hospital Medical Surge Preparedness Index Using a National Hospital Survey." *Health Service and Outcomes Research Methodology*, vol. 20, no. 1, 2020, pp. 60–83.

[67] National Health Security Preparedness Index. "Measures List: National Health Security Preparedness Index, 2021 Release." https://nhspi.org/wp-content/uploads/2021/06/2021-NHSPI-Measure-List.pdf.

[68] Ghosh, J.K., B. Martinez, C. Beck, and C. Rogers. "Community Outbreak Preparedness Index (COPI)." Heluna Health, October 2023. COPI_Technical_Report_October_2023.pdf.

[69] Gray, B., J. Eaton, J. Christy, J. Duncan, F. Hanna, and S. Kasi. "A Proactive Approach: Examples for Integrating Disaster Risk Reduction and Mental Health and Psychosocial Support Programming." *International Journal of Disaster Risk Reduction*, vol. 15, no. 54, 2021. https://doi.org/10.1016/j.ijdrr.2021.102051.

[70] Cutter, S., C. Burton, and C.T. Emrich. "Disaster Resilience Indicators for Benchmarking Baseline Conditions." Journal of Homeland Security and Emergency Management, vol. 7: no. 1, August 2010. https://doi.org/10.2202/1547-7355.1732.

[71] Peacock, W.G., S.D. Brody, W.A. Seitz, W.J. Merrell, A. Vedlitz, S. Zahran, R.C. Harriss, et al. "Advancing Resilience of Coastal Localities: Developing, Implementing, and Sustaining the Use of Coastal Resilience Indicators: A Final Report." *Hazard Reduction & Recovery Center*, 2010, pp. 1–148.

[72] United States Census Bureau. 2020. *Community Resilience Estimates: Quick Guide*. Also available at https://www2.census.gov/data/experimental-data-products/community-resilience-estimates/2020/technical-document.pdf.

[73] Sherrieb, K., F.H. Norris, and S. Galea. "Measuring Capacities for Community Resilience." *Social Indicators Research*, vol. 99, no. 2, 2010, pp. 227–247.

[74] Surgo Ventures. "COVID-19 Community Vulnerability Index (CCVI) Methodology." 2020. https://covid-static-assets.s3.amazonaws.com/US-CCVI/COVID-19+Community+Vulnerability+Index+(CCVI)+Methodology.pdf.

[75] Tiwari, A., A.V. Dadhania, V.A.B. Ragunathrao, and E.R.A Oliveira. "Using Machine Learning to Develop a Novel COVID-19 Vulnerability Index (C19VI)." *Science of the Total Environment*, vol. 773, 2021, article 14565.

[76] Marvel, S.W., J.S. House, M. Wheeler, K. Song, Y.H. Zhou, F.A. Wright, W.A. Chiu, et al. "The COVID-19 Pandemic Vulnerability Index (PVI) Dashboard: Monitoring County-Level Vulnerability Using Visualization, Statistical Modeling, and Machine Learning." *Environmental Health Perspectives*, vol. 129, no. 1, 2021.

[77] Flanagan, B.E., E.W. Gregory, E.J. Hallisey, J.L. Heitgerd, and B. Lewis. "A Social Vulnerability Index for Disaster Management." *Journal of Homeland Security and Emergency Management*, vol. 8, no. 1, 2011.

[78] Rogers, C.J., B. Cutler, K. Bhamidipati, and J.K. Ghosh. "Preparing for the Next Outbreak: A Review of Indices Measuring Outbreak Preparedness, Vulnerability, and Resilience." *Preventive Medicine Reports*, vol. 35, 2023, article 102282. https://doi.org/10.1016/j.pmedr.2023.102282.

[79] Office of Disease Prevention and Health Promotion, U.S. Department of Health and Human Services. "Federal Plan for Equitable Long-Term Recovery and Resilience for Social, Behavioral, and Community Health." January 2022. Available at: https://health.gov/our-work/national-health-initiatives/equitable-long-term-recovery-and-resilience

[80] Boyce, M. "State-level public health preparedness indices as predictors of COVID-19 mortality outcomes: results from the United States of America in 2020." *Frontiers in Epidemiology*, December 2023. DOI: 10.3389/fepid.2023.1229718.

[81] Stoto, M., and C. Nelson. "Measuring and Assessing Public Health Emergency Preparedness: A Methodological Primer." *SSRN*, August 2023. http://dx.doi.org/10.2139/ssrn.4538548.

[82] Ghosh, J.K., B. Martinez, C. Beck, and C. Rogers. "Community Outbreak Preparedness Index (COPI)." Heluna Health, October 2023. COPI_Technical_Report_October_2023.pdf.

[83] Environmental Protection Agency (EPA). "Community Health Vulnerability Index.". July 2017. https://www.epa.gov/sites/default/files/2017-07/documents/community_health_vulnerability_index.pdf.

[84] Nallen, Joe. "ReadyMapper: A Digital Solution to Optimize Health System Resilience and Response During Wildfires." Crisis Ready, 2022. https://www.crisisready.io/optimizing-health-response-during-wild-fires-with-real-time-integrated-data/.

[85]National Weather Service. "TsunamiReady Guidelines."n.d. https://www.weather.gov/tsunamiready/guidelines.

[86] Hammer, J., D.G. Ruggieri, C. Thomas, and J. Caum. "Local Extreme Heat Planning: An Interactive Tool to Examine a Heat Vulnerability Index for Philadelphia, Pennsylvania." *Journal of Urban Health*, vol. 97, no. 4, 2020, pp. 519–528. https://doi.org/10.1007/s11524-020-00443-9.

[87] Moore, M., B. Gelfeld, and C.P. Adeyemi Okunogbe. "Identifying Future Disease Hot Spots: Infectious Disease Vulnerability Index." *Rand Health Quarterly*, vol. 6, no. 3, 2017.

[88] Lee, J.M., R. Jansen, K.E. Sanderson, F. Guerra, S. Keller-Olaman, M. Murti, T.L. O'Sullivan, et al. "Public Health Emergency Preparedness for Infectious Disease Emergencies: A Scoping Review of Recent Evidence." *BMC Public Health*, vol. 23, no. 1, 2023, pp. 420. https://doi.org/10.1186/s12889-023-15313-7.

[89] Nallen, Joe. "ReadyMapper: A Digital Solution to Optimize Health System Resilience and Response During Wildfires." Crisis Ready, 2022. https://www.crisisready.io/optimizing-health-response-during-wild-fires-with-real-time-integrated-data/.

[90] National Health Security Preparedness Index. "Measures List: National Health Security Preparedness Index, 2021 Release." https://nhspi.org/wp-content/uploads/2021/06/2021-NHSPI-Measure-List.pdf.

[91] Ghosh, J.K., B. Martinez, C. Beck, and C. Rogers. "Community Outbreak Preparedness Index (COPI)." Heluna Health, October 2023. COPI_Technical_Report_October_2023.pdf.

[92] Glik, D.C., D.P. Eisenman, I. Donatello, A. Afifi, M. Stajura, M.L. Prelip, J. Sammartinova, et al. "Reliability and Validity of the Assessment for Disaster Engagement with Partners Tool (ADEPT) for Local Health Departments." *Public Health Reports*, vol. 129, no. 6, suppl. 4, 2014, pp. 77–86. https://doi.org/10.1177/00333549141296S411.

[93] Dorn, B.C., E. Savoia, M.A. Testa, M.A. Stoto, and L.J. Marcus. "Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance." *Public Health Reports,* vol. 122, no. 3, 2007, pp. 329-38. doi: 10.1177/003335490712200306. PMID: 17518304; PMCID: PMC1847495. Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance - PMC (nih.gov).

[94] Boyce, M.R., and R. Katz. "Rapid Urban Health Security Assessment Tool: A New Resource for Evaluating Local-Level Public Health Preparedness." *BMJ Global Health*, vol. 5, no. 6, 2020, article e002606.

[95] Centers for Disease Control and Prevention. "Public Health Emergency Preparedness and Response Capabilities: National Standards for State, Local, Tribal, and Territorial Public Health." October 2018. https://www.cdc.gov/orr/readiness/00_docs/CDC_PreparednesResponseCapabilities_October2018_Final_508.pdf.

[96] Assistant Secretary for Preparedness and Response. "2017–2022 Health Care Preparedness and Response Capabilities." November 2016. https://www.phe.gov/Preparedness/planning/hpp/reports/Documents/2017-2022-healthcare-pr-capablities.pdf.

[97] Federal Emergency Management Agency. "National Preparedness Goal." U.S. Department of Homeland Security, September 2015. https://www.fema.gov/sites/default/files/2020-06/national_preparedness_goal_2nd_edition.pdf.

[98] Dorn, B.C., E. Savoia, M.A. Testa, M.A. Stoto, and L.J. Marcus. "Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance." *Public Health Reports,* vol. 122, no. 3, 2007, pp. 329-38. doi: 10.1177/003335490712200306. PMID: 17518304; PMCID: PMC1847495. Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance - PMC (nih.gov).

[99] Ghosh, J.K., B. Martinez, C. Beck, and C. Rogers. "Community Outbreak Preparedness Index (COPI)." Heluna Health, October 2023. COPI_Technical_Report_October_2023.pdf.

[100] Acosta, J.D., L. Burgette, A. Chandra, D.P. Eisenman, I. Gonzalez, D. Varda, and L. Xenakis. "How Community and Public Health Partnerships Contribute to Disaster Recovery and Resilience." *Disaster Medicine and Public Health Preparedness,* vol. 12, no. 5, 2018, pp. 635–643. https://doi.org/10.1017/dmp.2017.130.

[101] Adams, R.M., M.L. Prelip, D.C. Glik, I. Donatello, and D.P. Eisenman. "Facilitating Partnerships with Community- and Faith-Based Organizations for Disaster Preparedness and Response: Results of a National Survey of Public Health Departments." *Disaster Medicine and Public Health Preparedness*, vol. 12, no. 1, 2018, pp. 57–66. https://doi.org/10.1017/dmp.2017.3.

[102] Brewer, L.C., G. Asiedu, C. Jones, M. Richard, J. Erickson, J. Weis, A. Abbenyi, et al. "Emergency Preparedness and Risk Communication Among African American Churches: Leveraging a Community-Based Participatory Research Partnership COVID-19 Initiative." *Preventing Chronic Disease*, vol. 17, 2020. https://doi.org/10.5888/pcd17.200408.

[103] Glik, D.C., D.P. Eisenman, I. Donatello, A. Afifi, M. Stajura, M.L. Prelip, J. Sammartinova, et al. "Reliability and Validity of the Assessment for Disaster Engagement with Partners Tool (ADEPT) for Local Health Departments." *Public Health Reports*, vol. 129, no. 6, suppl. 4, 2014, pp. 77–86. https://doi.org/10.1177/00333549141296S411.

[104] Marcozzi, D.E., R. Pietrobon, J.V. Lawler, M.T. French, C. Mecher, J. Peffer, N.E. Baehr, et al. "Development of a Hospital Medical Surge Preparedness Index Using a National Hospital Survey." *Health Service and Outcomes Research Methodology*, vol. 20, no. 1, 2020, pp. 60–83.

[105] Administration for Strategic Preparedness and Response. "2019–2023 Hospital Preparedness Program: Performance Measures Implementation Guidance." 2022. https://aspr.hhs.gov/HealthCareReadiness/guidance/Documents/2019-2023-HPP-Performance-Measures-Implementation-Guidance-8Nov22.pdf.

[106] National Association of County and City Health Officials. "Administrative Preparedness: Emergency Reporting Practices for Health Departments." September 2013. https://www.naccho.org/uploads/header-images/public-health-preparedness/Admin-Prep_Reporting.pdf.

[107] Centers for Disease Control and Prevention. "Public Health Emergency Preparedness and Response Capabilities: National Standards for State, Local, Tribal, and Territorial Public Health." October 2018. https://www.cdc.gov/orr/readiness/00_docs/CDC_PreparednesResponseCapabilities_October2018_Final_508.pdf.

[108] Gupta, N., S.A. Balcom, A. Gulliver, and R.L. Witherspoon. "Health Workforce Surge Capacity During the COVID-19 Pandemic and Other Global Respiratory Disease Outbreaks: A Systematic Review of Health System Requirements and Responses." *The International Journal of Health Planning and Management,* vol. 36, no. 1, 2021, pp. 26–41. https://doi.org/10.1002/hpm.3137.

[109] Stoto, M., and C. Nelson. "Measuring and Assessing Public Health Emergency Preparedness: A Methodological Primer." *SSRN*, August 2023. http://dx.doi.org/10.2139/ssrn.4538548.

[110] Moulton, A.D. "A COVID-19 Lesson: Better Health Emergency Preparedness Standards Are Needed." *Health Security*, vol. 20, no. 6, 2022, pp. 457–466. https://doi.org/10.1089/hs.2022.0037.

[111] Krieger, Nancy, Christian Testa, Jarvis T. Chen, William P. Hanage, and Alecia J. McGregor. "Relationship of Political Ideology of U.S. Federal and State Elected Officials and Key COVID Pandemic Outcomes Following Vaccine Rollout to Adults: April 2021–March 2022." *The Lancet Regional Health - Americas*, vol. 16, 2022, article 100384. https://doi.org/10.1016/j.lana.2022.100384.

[112] Pence, J., I. Miller, T. Sakurahara, J. Whitacre, S. Reihani, E. Kee, and Z. Mohaghegh. "GIS-Based Integration of Social Vulnerability and Level 3 Probabilistic Risk Assessment to Advance Emergency Preparedness, Planning, and Response for Severe Nuclear Power Plant Accidents." *Risk Analysis*, vol. 39, no. 6, 2019, pp. 1262–1280. https://doi.org/10.1111/risa.13241.

[113] Boyce, M. "State-level public health preparedness indices as predictors of COVID-19 mortality outcomes: results from the United States of America in 2020." *Frontiers in Epidemiology*, December 2023. DOI: 10.3389/fepid.2023.1229718.

[114] Stoto, M., and C. Nelson. "Measuring and Assessing Public Health Emergency Preparedness: A Methodological Primer." *SSRN*, August 2023. http://dx.doi.org/10.2139/ssrn.4538548.

[115] Grimmelikhuijsen, S & E. Knies. "Validating a scale for citizen trust in government organizations." *International Review of Administrative Sciences,* vol 83, no. 3, 2017, pp. 583 – 601. https://doi.org/10.1177/0020852315585950

[116] Burns, K, P. Brown, M. Calnan, P.R. Ward, J. Little et al. "Development and validation of the Trust in Government measure (TGM)". *BMC Public Health*, 2023. https://doi.org/10.1186/s12889-023-16974-0

[117] Pew Research Center. "Public Trust in Government: 1958 – 2024". June 2024.https://www.pewresearch.org/politics/2024/06/24/public-trust-in-government-1958-2024/

[118] SteelFisher, G., M. G. Finding, H.C. Caporello, K.M. Lubell, et al. "Trust in U.S. Federal, State, and Local Public Health Agencies During COVID-19: Responses and Policy Implications." *Health Affairs*, vol 42, no. 3, March 2023, pp. 328 – 337. https://doi.org/10.1377/hlthaff.2022.01204

[119] Ghosh, J.K., B. Martinez, C. Beck, and C. Rogers. "Community Outbreak Preparedness Index (COPI)." Heluna Health, October 2023. COPI_Technical_Report_October_2023.pdf.

[120] Federal Emergency Management Agency. "Pre-Disaster Recovery Planning Guide for Tribal Governments (FP 104-008-02)." U.S. Department of Homeland Security, September 2019. https://www.fema.gov/sites/default/files/2020-07/pre-disaster-recovery-planning-guide-for-tribal-government.pdf.

[121] Federal Emergency Management Agency. "2022–2026 FEMA National Tribal Strategy." U.S. Department of Homeland Security, 2022. https://www.fema.gov/sites/default/files/documents/fema_national-tribal-strategy_08182022.pdf.

[122] Lorenzoni, Nina, Stephanie Kainrath, Maria Unterholzner, and Harold Stummer. "Instruments for Disaster Preparedness Evaluation: A Scoping Review." *Australian Journal of Emergency Management*, vol. 37, no. 3, 2022, pp. 56.

[123] Moulton, A.D. "A COVID-19 Lesson: Better Health Emergency Preparedness Standards Are Needed." *Health Security*, vol. 20, no. 6, 2022, pp. 457–466. https://doi.org/10.1089/hs.2022.0037.

[124] Keim, M.E., and A.P. Lovallo. "Validity of the National Health Security Preparedness Index as a Predictor of Excess COVID-19 Mortality." *Prehospital and Disaster Medicine*, vol. 36, no. 2, 2021, pp. 141–144. https://doi.org/10.1017/S1049023X20001521.

[125] Kachali, Hlekiwe, Ira Haavisto, Riikka-Leena Leskelä, Auri Väljä, and Mikko Nuutinen. "Are Preparedness Indices Reflective of Pandemic Preparedness? A COVID-19 Reality Check." *International Journal of Disaster Risk Reduction*, vol. 77, 2022, pp. 2212–4209. https://doi.org/10.1016/j.ijdrr.2022.103074.

[126] NACCHOO, "2022 Preparedness Profile Study." 2023. https://www.naccho.org/uploads/downloadable-resources/2022PrepProfile-PREVIEWREPORT.pdf.

[127] National Health Security Preparedness Index. "Measures List: National Health Security Preparedness Index, 2021 Release." 2021. https://nhspi.org/wp-content/uploads/2021/06/2021-NHSPI-Measure-List.pdf.

[128] The White House. "National Cybersecurity Strategy." March 2023. https://www.whitehouse.gov/wp-content/uploads/2023/03/National-Cybersecurity-Strategy-2023.pdf.

[129] National Association of County and City Health Officials. "Hurricane and Flooding Preparedness Resources."2015. https://www.naccho.org/blog/articles/hurricane-and-flooding-preparedness-resources.

[130] National Association of County and City Health Officials. "2022 Preparedness Profile Study." 2023. https://www.naccho.org/uploads/downloadable-resources/2022PrepProfile-PREVIEWREPORT.pdf.

[131] National Health Security Preparedness Index. "Measures List: National Health Security Preparedness Index, 2021 Release." 2021. https://nhspi.org/wp-content/uploads/2021/06/2021-NHSPI-Measure-List.pdf.

[132] Qari, S.H., H.R. Yusuf, S.L. Groseclose, M.R. Leinhos, and E.G. Carbone. "Public Health Emergency Preparedness System Evaluation Criteria and Performance Metrics: A Review of Contributions of the CDC-Funded Preparedness and Emergency Response Research Centers." *Disaster Medicine and Public Health Preparedness,* vol. 13, no. 3, 2019, pp. 626–638. https://doi.org/10.1017/dmp.2018.110.

[133] Government Accountability Office. "COVID-19: Pandemic Lessons Highlight the Need for Public health Situational Network." 2022. https://www.gao.gov/products/gao-22-104600.

[134] Ibid.

[135] Lorenzoni, Nina, Stephanie Kainrath, Maria Unterholzner, and Harold Stummer. "Instruments for Disaster Preparedness Evaluation: A Scoping Review." *Australian Journal of Emergency Management*, vol. 37, no. 3, 2022, pp. 56.

[136] Ibid.

[137] Qari, S.H., H.R. Yusuf, S.L. Groseclose, M.R. Leinhos, and E.G. Carbone. "Public Health Emergency Preparedness System Evaluation Criteria and Performance Metrics: A Review of Contributions of the CDC-Funded Preparedness and Emergency Response Research Centers." *Disaster Medicine and Public Health Preparedness,* vol. 13, no. 3, 2019, pp. 626–638. https://doi.org/10.1017/dmp.2018.110.

[138] Institute of Medicine Committee on Post-Disaster Recovery of a Community's Public Health, Medical, and Social Services. "Healthy, resilient, and sustainable communities after disasters: strategies, opportunities, and planning for recovery." Washington (DC): National Academies Press (US); 2015 Sep 10. Available from: https://www.ncbi.nlm.nih.gov/books/NBK316532/ doi: 10.17226/18996.

[139] Stribling, J., A. Clifton, G. McGill, and K. de Vries. "Examining the UK Covid-19 Mortality Paradox: Pandemic Preparedness, Healthcare Expenditure, and the Nursing Workforce." *Journal of Advanced Nursing*, vol. 76, no. 12, 2020, pp. 3218–3227. https://doi.org/10.1111/jan.14562.

[140] Kaiser, M.A., T.Y. Chen, and P. Gluckman. "Should Policy Makers Trust Composite Indices? A Commentary on the Pitfalls of Inappropriate Indices for Policy Formation." Health Research Policy and Systems, vol. 19, no.1, March 2021. https://doi.org10.1186/s12961-021-00702-4.

[141] Keim, M.E., and A.P. Lovallo. "Validity of the National Health Security Preparedness Index as a Predictor of Excess COVID-19 Mortality." *Prehospital and Disaster Medicine*, vol. 36, no. 2, 2021, pp. 141–144. https://doi.org/10.1017/S1049023X20001521.

[142] Choo, E.K. "COVID-19 Fault Lines." *Lancet,* vol. 395, no. 10233, 2020, pp. 1333. https://doi.org/10.1016/S0140-6736(20)30812-6.

[143] Liao, T.F., and F. De Maio. "Association of Social and Economic Inequality with Coronavirus Disease 2019 Incidence and Mortality Across US Counties." *JAMA Network Open*, vol. 4, no. 1, 2021, article e2034578. https://doi.org/10.1001/jamanetworkopen.2020.34578.

[144] Mays, G., and M. Childress. "2021 Release of National Health Security Preparedness Index." University of Colorado, Colorado School of Public Health, June 2021.

[145] Centers for Disease Control and Prevention. "Public Health Response Readiness Framework: 2024-–2028 Program Priorities – Defines Excellence in Response Operations." 2024. https://www.cdc.gov/orr/readiness/phep/00_docs/CDC-PHEP-Response-Readiness-Framework_January-2024_508c.pdf.

[146] American Medical Association, Planned Parenthood Federation of America, American Association of Public Health Physicians, National Birth Equity Collaborative, American College of Preventive Medicine, American Public Health Association, For the Culture Consulting, LLC, and New York City Pandemic Response Institute. "Embedding Equity in Crisis Preparedness and Response." 2023. https://www.ama-assn.org/about/ama-center-health-equity/embedding-equity-crisis-preparedness-and-response-health-systems. Accessed May 10, 2024.

[147] Congressional Research Service. "Tracking COVID-19: U.S. Public Health Surveillance and Data." 2020. https://crsreports.congress.gov/product/pdf/R/R46588.

[148] Centers for Disease Control and Prevention. "Data Modernization Initiative website." n.d. https://www.cdc.gov/surveillance/data-modernization/index.html. Accessed May 2, 2024.

[149] National Academies of Sciences, Engineering, and Medicine. "Evidence Based Practice for Public Health Emergency Preparedness and Response." 2020.

[150] Samet, J. and R.C. Brownson. "Reimagining Public Health: Mapping a Path Forward". Health Affairs, vol. 43, no. 6, 2024, pp. 750 – 758. https://doi.org/10.1377/hlthaff.2024.00007.

[151] Lichiello, P., and B. Turnock. *Guidebook to Performance Management.* 1999. https://www.phf.org/resourcestools/documents/pmcguidebook.pdf.

[152] Ibid.

[153] Roper, W., and B. Mays. "Performance Measurement in Public Health: Conceptual and Methodological Issues in Building the Science Base." *Journal of Public Health,* September 2000.

[154] McDavid, J. C., and L.R.L. Hawthorn, L. R. L. *Program Evaluation and Performance Measurement: An Introduction to Practice.* Sage Publications, Inc, 2006.

[155] Roper, W., and B. Mays. "Performance Measurement in Public Health: Conceptual and Methodological Issues in Building the Science Base." *Journal of Public Health,* September 2000.

[156] Ibid.

[157] Cox, R., and M. Hamlen. "Community Disaster Resilience and the Rural Resilience Index." American Behavioral Scientist, vol. 59, no. 2, February 2015.

[158] Lorenzoni, Nina, Stephanie Kainrath, Maria Unterholzner, and Harold Stummer. "Instruments for Disaster Preparedness Evaluation: A Scoping Review." *Australian Journal of Emergency Management*, vol. 37, no. 3, 2022, pp. 56.

[159] Glik, D.C., D.P. Eisenman, I. Donatello, A. Afifi, M. Stajura, M.L. Prelip, J. Sammartinova, et al. "Reliability and Validity of the Assessment for Disaster Engagement with Partners Tool (ADEPT) for Local Health Departments." Public Health Reports, vol. 129, no. 6, suppl. 4, 2014, pp. 77–86. https://doi.org/10.1177/00333549141296S411.

[160] Acosta, J.D., L. Burgette, A. Chandra, D.P. Eisenman, I. Gonzalez, D. Varda, and L. Xenakis. "How Community and Public Health Partnerships Contribute to Disaster Recovery and Resilience." Disaster Medicine and Public Health Preparedness, vol. 12, no. 5, 2018, pp. 635–643. https://doi.org/10.1017/dmp.2017.130.

[161] Dorn, B.C., E. Savoia, M.A. Testa, M.A. Stoto, and L.J. Marcus. "Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance." *Public Health Reports,* vol. 122, no. 3, 2007, pp. 329-38. doi: 10.1177/003335490712200306. PMID: 17518304; PMCID: PMC1847495. Development of a Survey Instrument to Measure Connectivity to Evaluate National Public Health Preparedness and Response Performance - PMC (nih.gov).

[162] Ibid.

[163] Technical Resources, Assistance Center, and Information Exchange. "ASPR TRACIE Emergency Preparedness Information Modules for Nurses in Acute Care Settings," February 2022. https://files.asprtracie.hhs.gov/documents/aspr-tracie-emergency-preparedness-information-modules-for-nurses-and-economic-framework.pdf. Accessed May 10, 2024.

[164] Society for Healthcare Epidemiology of America. "Outbreak Response Training Program." https://learningce.shea-online.org/content/sheacdc-outbreak-response-training-program-ortp#group-tabs-node-course-default1. Accessed May 10, 2024.

[165] Haan, Katherine. "Best Learning Management Systems (LMS) of 2024." Forbes Advisor, April 8, 2024. https://www.forbes.com/advisor/business/best-learning-management-systems/#:~:text=Learning%20management%20systems%2C%20or%20LMS%2C%20are%20software%20platforms,as%20to%20provide%20compliance%20training%20or%20customer%20education. Accessed May 10, 2024.

[166] National Association of County and City Health Officials. "2022 Preparedness Profile Study." 2023. https://www.naccho.org/uploads/downloadable-resources/2022PrepProfile-PREVIEWREPORT.pdf.

[167] Choo, E.K. "COVID-19 Fault Lines." Lancet, vol. 395, no. 10233, 2020, pp. 1333. https://doi.org/10.1016/S0140-6736(20)30812-6; Liao, T.F., and F. De Maio. "Association of Social and Economic Inequality with Coronavirus Disease 2019 Incidence and Mortality Across US Counties." *JAMA Network Open*, vol. 4, no. 1, 2021, article e2034578. https://doi.org/10.1001/jamanetworkopen.2020.34578.

[168] Krieger, Nancy, Christian Testa, Jarvis T. Chen, William P. Hanage, and Alecia J. McGregor. "Relationship of Political Ideology of U.S. Federal and State Elected Officials and Key COVID Pandemic Outcomes Following Vaccine Rollout to Adults: April 2021–March 2022." *The Lancet Regional Health - Americas*, vol. 16, 2022, article 100384. https://doi.org/10.1016/j.lana.2022.100384; Technical Expert Panel.

[169] Stoto, M., and C. Nelson. "Measuring and Assessing Public Health Emergency Preparedness: A Methodological Primer." *SSRN*, August 2023. http://dx.doi.org/10.2139/ssrn.4538548; Technical Expert Panel.

[170] Brown, Lisa M., Kathryn Hyer, and LuMarie Polivka-West, "A comparative study of laws, rules, codes and other influences on nursing homes' disaster preparedness in the Gulf Coast states." *Behavioral Sciences & the Law*, vol. 25, no. 5, September 2007, pp. 655-675. https://doi.org/10.1002/bsl.785.

[171] Botoseneanu, A., H. Wu, J. Wasserman, P.D. Jacobson, "Achieving public health legal preparedness: how dissonant views on public health law threaten emergency preparedness and response." *Journal of Public Health*, vol. 33, no. 3, September 2011, pp. 361-368. https://doi.org/10.1093/pubmed/fdq092.

[172] Chowdhury, P., S. Kumar Paul, S. Kaisar, and Md. A. Moktadir. "COVID-19 Pandemic Related Supply Chain Studies: A Systematic Review. *Trnsp Res E Logist Transp Rev*. April 2021, 148: 102271. doi: 10.1016/j.tre.2021.102271.

[173] DeSalvo, K., B. Hughes, M. Bassett, G. Benjamin, M. Fraser, S. Galea, N. Garcia, and J. Howard. 2021. "Public Health COVID-19 Impact Assessment: Lessons Learned and Compelling Needs." NAM Perspectives. Discussion Paper, National Academy of Medicine, Washington, DC. https://doi.org/10.31478/202104c.

[174] Burke, Marshall, Anne Driscoli, Sam Huft-Neal, Jiani Xue, Jennifer Burney, and Michael Wara, "The changing risk and burden of wildfire in the United States." *PNAS* vol. 118, no. 2, 2021. https://doi.org/10.1073/pnas.2011048118.

[175] Mannucci, Simona, Federica Rosso, Alessandro D'Amico, Gabriele Bernardini, and Michele Morganti, "Flood resilience and adaptation in the built environment: how far along are we?" Sustainability, vol. 14 no. 7, March 2022, 4096; https://doi.org/10.3390/su14074096.

[176] Brown, Lisa M., Kathryn Hyer, and LuMarie Polivka-West, "A comparative study of laws, rules, codes and other influences on nursing homes' disaster preparedness in the Gulf Coast states." Behavioral Sciences & the Law, vol. 25, no. 5, September 2007, pp. 655-675. https://doi.org/10.1002/bsl.785.

[177] Choo, E.K. "COVID-19 Fault Lines." Lancet, vol. 395, no. 10233, 2020, pp. 1333. https://doi.org/10.1016/S0140-6736(20)30812-6; Liao, T.F., and F. De Maio. "Association of Social and Economic Inequality with Coronavirus Disease 2019 Incidence and Mortality Across US Counties." *JAMA Network Open*, vol. 4, no. 1, 2021, article e2034578. https://doi.org/10.1001/jamanetworkopen.2020.34578.

[178] Centers for Disease Control and Prevention. "Public Health Response Readiness Framework: 2024-2028 Program Priorities – Defines Excellence in Response Operations." CDC. https://www.cdc.gov/orr/readiness/phep/00_docs/CDC-PHEP-Response-Readiness-Framework_January-2024_508c.pdf.

[179] Mays, G., and M. Childress. "2021 Release of National Health Security Preparedness Index." University of Colorado, Colorado School of Public Health, June 2021.

[180] Federal Emergency Management Agency. "After-Action Review User Guide." November 2023. https://preptoolkit.fema.gov/documents/d/cip-citap/after_action_review_user_guide_november_2023_f?download=true.

[181] Federal Emergency Management Agency. "National Preparedness Goal." March 2023. https://www.fema.gov/emergency-managers/national-preparedness/goal. Accessed May 6, 2024

[182] National Academies of Sciences, Engineering, and Medicine. "Evidence Based Practice for Public Health Emergency Preparedness and Response." 2020.

[183] Knox, C. C. "Systematic Analysis of After-Action Reports: A Plan Evaluation Methodological Approach." *Nat. Hazards Rev.*, vol. 22, no. 4, 2021. https://ascelibrary.org/doi/10.1061/%28ASCE%29NH.1527-6996.0000519.

[184] FEMA. "Homeland Security Exercise Evaluation Program." Undated. https://preptoolkit.fema.gov/web/hseep-resources.

[185] TRACIE. "COVID After-Action Report Resources and Examples." January 19, 2023. https://files.asprtracie.hhs.gov/documents/aspr-tracie-covid-19-after-action-reports---7-21-2021-508.pdf.

[186] Naik, R., N. Maxwell, T. Jones, and S. A. Dopson. "Public Health Emergency Preparedness: Qualitative Analysis of After-Action Reports. Disaster Medicine and Public Health Preparedness, vol. 17, 2023, e523. doi: https://doi.org/10.1017/dmp.2023.201.

[187] Piltch-Loeb, R.N., C. Nelson, J. Kraemer, E. Savoia, and M. Stoto. "s." Public Health Reports, vol. 129, no. 6, November 2014, pp. 28–34. https://doi.org/10.1177/00333549141296S405.

[188] Administration for Strategic Preparedness and Response. "2019–2023 Hospital Preparedness Program: Performance Measures Implementation Guidance." 2022. https://aspr.hhs.gov/HealthCareReadiness/guidance/Documents/2019-2023-HPP-Performance-Measures-Implementation-Guidance-8Nov22.pdf.

Appendix A. Methods

The study included an environmental scan, a technical expert panel (TEP), a synthesis analysis of themes and gaps in current metrics, and a synthesis analysis of strategies to advance public health preparedness metrics. In this appendix, we describe our study methods.

A. Environmental scan

With support from our partner, MDB, Inc., we conducted an environmental scan. The primary goal of the scan was to learn about existing domestic and international public health and health-care preparedness measures, indices, and inventories (which we collectively describe as "tools"). Although the focus of this project is on domestic preparedness, the inclusion of articles focusing on global tools that assess nation-level preparedness provided valuable insights and perspectives that enhanced and broadened understanding of this topic.

We identified peer-reviewed and gray literature for the environmental scan by systematically searching PubMed and Web of Science databases and select government agency and preparedness-tool websites. We supplemented these searches with targeted Google searches. We applied the following exclusion criteria to literature returned through the searches that:

- Focused on individual or household emergency preparedness (for example, checklists to assess emergency preparedness at the household level)
- Focused on studies or tools that measure preparedness at the subnational level in countries outside the United States (for example, comparing disaster preparedness in French pediatric hospitals)
- Did not focus on any phase of the emergency preparedness cycle (for example, articles describing post-disaster outcomes that did not also assess elements of prevention, protection, mitigation, response, and recovery)
- Did not describe efforts to *measure* preparedness (for examples, articles describing emergency training curricula for health and public health workers)
- Summarized after-action reports and lessons learned from individual public health agencies

Below, we describe our approaches to identifying relevant literature.

1. *Searched PubMed and Web of Science for peer-reviewed journal articles*: From October through December 2023, we conducted searches of PubMed and Web of Science records using search terms related to public health (and variations such as community health and population health); medical systems (including variations such as health infrastructure and hospitals); emergencies, disasters, and hazards; preparedness, readiness, resilience, and vulnerability; and measurement (including variations such as measures, scores, index, and scorecard).[13] We restricted the PubMed and Web of Science searches to articles published after 2012 to focus on recent tools and research, and applied the exclusion criteria listed above to the returned articles.

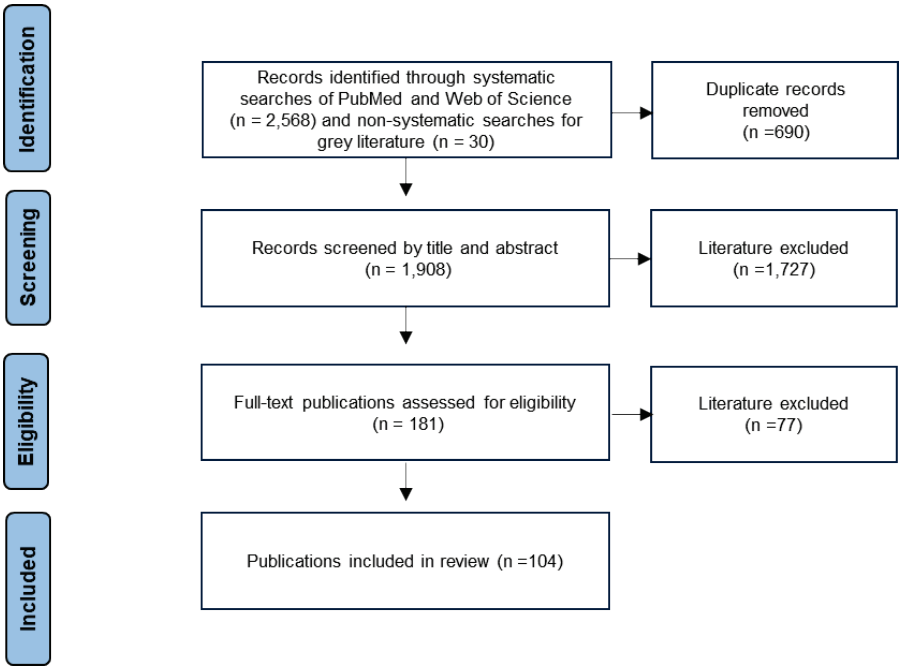
[13] This list of search terms is not exhaustive.

2. *Searched government agency and preparedness-tool websites:* In April 2024, we conducted focused searches on the websites of key government agencies and prominent preparedness-tool websites to identify relevant publications on public health or health preparedness. We then applied the exclusion criteria described above to the returned literature. We searched webpages for the following organizations and agencies: the Centers for Disease Control and Prevention, Administration for Strategic Preparedness and Response, the Federal Emergency Management Administration, National Association of County and City Health Officials (NACCHO), the Association of State and Territorial Health Officials (ASTHO), Pan American Health Organization, National Health Security Preparedness Index (NHSPI), and Trust for America's Health.
3. *Conducted targeted Google searches:* The peer-reviewed and gray literature included scoping reviews that mentioned a few U.S.-based tools that were not associated with articles returned from the searches noted above. To learn more about these tools, we conducted additional targeted Google searches using the tool name as the search term.

Initial PubMed and Web of Science searches for peer-reviewed literature returned 1,878 articles. After applying exclusion criteria, we identified 74 articles to include in the full-text review. Our searches for gray literature on federal agency websites, preparedness-tool websites, and Google yielded an additional 30 documents.

In total, we closely reviewed 104 pieces of peer-reviewed and gray literature (Exhibit A.1). From each of these articles, we extracted information identifying the tool being discussed (if any), challenges in measuring preparedness, and key findings related to measuring public health and health-care preparedness. We highlight key findings from the environmental scan in Chapter II, although we cite relevant sources throughout the report.

Exhibit A.1. Identification of literature via databases and supplemental searches



B. Technical expert panel

Our partner, MDB, Inc., convened a technical expert panel (TEP) in January 2024, composed of 20 experts from federal agencies, public health and health-care organizations, and academia (a complete list of TEP members and their affiliations is in Appendix D). We identified TEP members with a background in public health or health preparedness, an understanding of metrics, and broad knowledge of current disaster threats. We attempted to identify a subset of TEP members who represent the perspectives of populations that are socially vulnerable, given the challenges in reaching these populations and disparities in post-disaster outcomes.

MDB conducted the two-hour TEP meeting virtually, facilitating a combination of breakout group and main group discussions. The breakout group portion of the meeting consisted of three small group discussions facilitated by MDB and Mathematica staff. Throughout the meeting, TEP members discussed (1) the strengths and weaknesses of current measures, drawing on findings from the scan and their own experiences; (2) key takeaways from the COVID-19 pandemic; and (3) considerations for future preparedness measurement efforts, including new data sources that could be captured in measures. Appendix E presents the full TEP meeting agenda.

A notetaker captured comments from TEP members, which was subsequently used for thematic analysis. We coded the findings to understand the relative frequency of different themes and the prevalence of these themes across breakout groups. Unless otherwise noted, all TEP findings and quotations included in this report were mentioned by at least three TEP members across two or more breakout groups. TEP findings are interweaved with literature findings throughout the report.

C. Analysis of themes and gaps in current preparedness metrics

Using data from the environmental scan and the TEP, we analyzed themes and gaps in current U.S. preparedness metrics related to eight characteristics (Exhibit A.2), which we summarize in Chapter II. Our approach to assessing themes and gaps varied by characteristic, as some characteristics are relevant at the *tool level* (for example, the types and intended users of indices) whereas others are relevant at the *measure level* (for example, the data source for a measure of preparedness).

Exhibit A.2. Characteristics of preparedness metrics assessed in the analysis of themes and gaps

Characteristic	Level of analysis
Types of available tools	Tool level
Purpose	Tool level
Intended users	Tool level
How metrics conceptualize preparedness	Tool and measure levels
Types of disasters addressed	Tool level
Jurisdiction levels	Tool level
Data sources	Measure level
Preparedness factors being measured	Measure level

For *tool-level characteristics*, we used the literature from the environmental scan to develop a de-duplicated summary table of U.S.-based preparedness tools and their characteristics (Appendix B). We

defined "preparedness tools" as tools that assessed national, state, or local capacity in two or more phases of the emergency preparedness cycle (that is, prevention, protection, mitigation, response, and recovery). We did not include tools that (1) exclusively measure nation-level preparedness, (2) measure subnation level preparedness outside the United States, or (3) measure a single phase of preparedness (for example, vulnerability and resilience indices). From the 104 documents that we reviewed as part of the environmental scan, we identified 12 existing preparedness tools at the STLT (state, tribal, local, or territorial) level. Each article did not present a unique tool; many of these articles focused on the same tools and metrics (most commonly, the NHSPI). We used the summary table to describe the frequencies of tool-level characteristics across existing tools and to identify gaps in these characteristics. We synthesized these findings with others from the literature and the TEP and highlighted in the report any inconsistencies across data sources.

For *measure-level characteristics*, we relied on the synthesis of TEP and literature findings to identify themes and gaps. We approached the measure-level analysis this way because it was not feasible to develop a comprehensive, de-duplicated list of existing measures, given the vast number of measures across existing tools. We summarize the findings from the themes and gap analysis in Chapter II.

D. Analysis of strategies to advance preparedness measurement

To inform the analysis of strategies to advance preparedness measurement (Chapter III), we first reviewed literature on public health performance measurement to understand important attributes of metrics and the extent to which these attributes are missing from existing preparedness metrics, as identified in the gaps analysis. We then reviewed TEP findings to identify strategies the TEP members had suggested to address the gaps in existing metrics. We synthesized TEP findings with themes from the literature to develop the list of proposed strategies in Chapter III.

Appendix B. Tools to Measure State, Local, Tribal, and Territorial Public Health and Health Care Preparedness in the United States

Tool	Type of tool	Hazard	Domain(s)	Jurisdiction level(s)	Data source	Intended users	Strengths	Weaknesses
ASPR's Hospital Preparedness Program performance measure set (ASPR 2022)	Measure set	AH	• Foundation for Health Care and Medical Readiness • Health Care and Medical Response Coordination • Continuity of Health Care Service Delivery • Medical Surge	National HPP funding recipient (state, territorial, large local) HCC (local/ substate) level	Data self-reported by funding recipients; ASPR shares data publicly	Federal officials State and local officials HCCs and local multi-sector coalitions General public	Some measures are at the HCC (local) level so may be relevant and actionable for communities to use for planning	Most data are reported at the level of the funding recipient (generally state and territorial). HCCs are not consistent sizes and are not always comparable. Earlier assessments of the HPP measures in a 2013 GAO report noted the need for annual benchmarks to support progress over time.[a]
Assessment for Disaster Engagement with Partners Tool (ADEPT) (Glik et al. 2014)	Index	AH	• Communication outreach and coordination • Resource mobilization • Organizational capacity building • Partnership development and maintenance	Local	Data self-reported/ self-administered by local health departments	Local health departments	Captures valuable information on the linkages between LHDs and CBOs/FBOs for disaster information, resources, shelter, and other assistance	Evidence of the tool's validity and predictive capacity in real-world emergencies is limited.

Tool	Type of tool	Hazard	Domain(s)	Jurisdiction level(s)	Data source	Intended users	Strengths	Weaknesses
Community Outbreak Preparedness Index (Ghosh et al. 2023)	Index	ID	• Health-care system preparedness • Public health system preparedness • Access to health insurance and social safety net services • Community factors	Local	NACHHO data; FEMA data; American Hospital Association Survey; National Provider Identifier; other sources	STLT public health officials and partners; policy makers	Fills a gap in indices specific to local agencies	The new tool is not widely validated or researched in different local contexts.
Connectivity Measurement Tool (Dorn et al. 2007)	Index	AH	• System • Coworker • Organization • Individual	Local (individual, organization and/or system)	Self-administered questionnaire	STLT emergency preparedness agencies and organizations	Authors believe that aggregated scores collected from specific organizations or systems provide data that can be used for comparative purposes	Self-reported data are prone to response bias. The tool does not include an assessment of performance in relation to connectivity.
Hospital Medical Surge Preparedness Index (Marcozzi et al. 2020)	Index	AH	• Staff • Supplies • Space • System	Local (facility/hospital)	American Hospital Association annual survey data, U.S. Census Bureau, and the Dartmouth Atlas project	Hospital administrators Regional and state emergency planners	Hospital-level data provide granular information that can be aggregated to inform state and regional emergency planners	The index fails to measure synergies between hospitals to improve collective response. The index has not been validated in relation to hospital performance in the face of actual disasters.

Tool	Type of tool	Hazard	Domain(s)	Jurisdiction level(s)	Data source	Intended users	Strengths	Weaknesses
National Health Security Preparedness Index	Index	AH	• Health security and surveillance • Community planning and engagement • Incident and information management • Health care delivery • Countermeasures management • Environmental and occupational health	National State	64 data sources, including surveys (i.e., BRFSS, ASTHO profiles, Comprehensive Laboratory Services Survey, All-Hazards Laboratory Preparedness Survey, and others), safety inspection results, and federal administrative records	Federal, state, and local officials Multisector coalitions Researchers General Public	ASTHO coordinated input from a wide range of stakeholders to develop the tool in 2013 Served as one of the first tools to assess all-hazards preparedness at the sub-national level in the United States There is some evidence that high preparedness scores were associated with lower death rates during the COVID-19 pandemic[a,b]	There is evidence that the NHSPI is not a valid predictor of excess COVID-19 mortality rates for 50 U.S. states and Puerto Rico during the first six months of the pandemic.[c]

Tool	Type of tool	Hazard	Domain(s)	Jurisdiction level(s)	Data source	Intended users	Strengths	Weaknesses
Preparedness Capacity Assessment Survey (Davis et al. 2013) .	Index	AH	• Surveillance and investigation • Plans and protocols • Workforce and volunteers • Communication and information dissemination • Incident command • Legal infrastructure and preparedness • Emergency events and exercises • Corrective action activities	Local	Survey completed by local health departments	State and local health departments	The domains reflect the essential and vital capacities for local and state health departments to effectively build and maintain their preparedness capabilities	Data are self-reported and may contain potential response bias. The tool is not designed for comparison across jurisdictions.
Rapid Urban Health Security Assessment (RUHSA) (Boyce and Katz 2020)	Measure set	AH	• Prevent public health emergencies • Detect public health emergencies • Respond to public health emergencies • Other considerations	Local	Internal data used for self-assessment	Local government leaders and policymakers	Assesses immediate capacity to respond to disease and health threats at the local level	RUHSA is a self-assessment tool, so does not allow for comparison or benchmarking against other similar jurisdictions. Designed specifically for urban jurisdictions, the tool is not applicable to rural jurisdictions.

Tool	Type of tool	Hazard	Domain(s)	Jurisdiction level(s)	Data source	Intended users	Strengths	Weaknesses
Trust for America's Health Ready or Not tool (McKillop 2024)	Measure set	AH	• Incident management • Institutional quality • Water security • Workforce resiliency and infection control • Countermeasure utilization • Patient safety • Health security surveillance • Public health system comprehensiveness (not included in 2024 report)	National (summarizes number of states in high, medium, and low tiers) State	NHSPI data sources and state public health expenditure data collected and analyzed by TFAH	Federal, state, and local officials; general public; researchers;	Includes a narrower set of measures than NHSPI, allowing for focused attention to guide stakeholders in improvement efforts. High TFAH preparedness scores were generally, but not uniformly, associated with lower death rates.[a]	The tool's narrow set of goals does not consider the full range of risks that a jurisdiction may face.

Note: Strengths and weaknesses were cited within the source for each tool, unless otherwise noted. AH = all hazards; AHA = American Hospital Association; ASPR = Administration for Strategic Preparedness and Response; ASTHO = Association of State and Territorial Health Officials; BRFSS = Behavioral Risk Factor Surveillance System; CBO = community-based organization; FBO = faith based organization; FEMA = Federal Emergency Management Agency; HCC = health care coalition; ID = infectious disease; LHD = local health department; NHSPI = National Health Security Preparedness Index; STLT = state, tribal, local, or territorial; TFAH = Trust for American Health index.

[a] Moulton, A.D. "A COVID-19 Lesson: Better Health Emergency Preparedness Standards Are Needed." Health Security, vol. 20, no. 6, 2022, pp. 457–466. https://doi.org/10.1089/hs.2022.0037.

[b] Mays, G., and M. Childress. "2021 Release of National Health Security Preparedness Index." University of Colorado, Colorado School of Public Health, June 2021.

[c] Keim, M.E., and A.P. Lovallo. "Validity of the National Health Security Preparedness Index as a Predictor of Excess COVID-19 Mortality." Prehospital and Disaster Medicine, vol. 36, no. 2, 2021, pp. 141–144. https://doi.org/10.1017/S1049023X20001521.

Appendix C. Summary of Literature Assessing the Extent to Which Preparedness Indices Predicted Outcomes During the COVID-19 Pandemic

Title	Author (date)	Tool discussed	Key findings
Examining the UK Covid-19 mortality paradox: pandemic preparedness, health-care expenditure, and the nursing workforce	Stribling et al. (2020)	Global Health Security (GHS) Index	Country-level mortality rates do not appear to be related to the GHS Index in a manner that would be expected. The top 3 scoring countries on the GHS Index (United States, United Kingdom, and the Netherlands) all have relatively high mortality rates, while Canada (ranked 5th on the GHS Index) has a moderate mortality rate, but Australia and Thailand (ranked 4th and 6th, respectively) have a very low mortality rate.
Validity of the National Health Security Preparedness Index as a predictor of excess COVID-19 mortality	Keim and Lovallo (2021)	National Health Security Preparedness Index (NHSPI)	The NHSPI tool did not appear to be a valid predictor of excess COVID-19 mortality rates for the 50 U.S. states and Puerto Rico during the first 6 months of the pandemic (March–September 2020). Researchers found a high degree of variance and poor correlation between excess COVID-19 mortality rates compared to the overall score and to the 6 individual domains in the NHSPI.
Should policy makers trust composite indices? A commentary on the pitfalls of inappropriate indices for policy formation	Kaiser et al. (2021)	GHS Index	Composite preparedness indices like the GHS have several weaknesses, which may account for the inverted relationship between predicted vs. actual performance. Weaknesses identified include an inconsistent scoring system, arbitrary weighting of indicators, inclusion of indicators with questionable validity, inability to compare scores across countries, and inability to capture political bias.
The Global Health Security index and Joint External Evaluation score for health preparedness are not correlated with countries' COVID-19 detection response time and mortality outcome	Haider et al. (2020)	GHS Index Joint External Evaluation (JEE) for health preparedness	The GHS index and JEE were found to be strongly correlated, but both indices had a poor correlation with countries' COVID-19 related mortality outcomes and had low predictive value for detection response time from March 11–July 1, 2020.
Does it matter that standard preparedness indices did not predict COVID-19 outcomes?	Stoto and Nelson (2023)	GHS Index JEE for health preparedness	A country's success in dealing with a pandemic is highly multidimensional and may be too complex to represent with a single number, as provided by the GHS and JEE. Methodological issues identified include the comparability of mortality data due to highly variable completeness and representativeness and the inability to capture variations in the presence of effective political leadership.
The Global Health Security Index is not predictive of coronavirus pandemic responses among Organization for Economic Cooperation and Development countries	Abbey et al. (2020)	GHS Index	A rank-based analysis measuring total cases, total deaths, recovery rate, and total tests performed found a discrepancy between the GHS Index rating and the actual performance of Organization for Economic Cooperation and Development countries during the COVID-19 pandemic.

Title	Author (date)	Tool discussed	Key findings
Strengthening national capacities for pandemic preparedness: A cross-country analysis of COVID-19 cases and deaths	Duong et al. (2022)	IHR-SPAR GHS index Universal Health Coverage Service Coverage Index World Bank Worldwide Governance Indicator	Countries with higher GHS and IHR-SPAR scores experienced fewer reported COVID-19 cases and deaths but only for the first 8 weeks after the country's first case (for GHS, the association was limited to countries with populations below 69.4 million). The country-level rankings from the Universal Health Coverage Service Coverage Index and Worldwide Governance Indicator were not associated with COVID-19 outcomes.
A COVID-19 lesson: Better health emergency preparedness standards are needed	Moulton (2022)	NHSPI TFAH	High NHSPI and TFAH preparedness scores were generally, but not uniformly, associated with lower COVID-19 death rates. The measure of effectiveness of the pandemic response was measured by states' cumulative COVID-19 deaths per 100,000 population from January 1, 2020–January 20, 2022.
Are preparedness indices reflective of pandemic preparedness? A COVID-19 reality check	Kachali et al. (2022)	IHR GHS index	States' reported cumulative mortality rates during the first wave of the COVID-19 pandemic (spring 2020) were primarily negatively correlated with the expected preparedness rank, according to IHR and GHS.
Comparison of COVID-19 Resilience Index and its associated factors across 29 countries during the Delta and Omicron variant periods	Huy et al. (2022)	Pandemic resilience index	Across 29 countries, the percentage of the population fully vaccinated and high government indices scores were significantly associated with a better resilience index score in both the COVID-19 Delta and Omicron periods. The pandemic resilience index combines country-level mortality, hospital occupancy, and intensive care unit occupancy rates.
Global health security preparedness and response: An analysis of the relationship between Joint External Evaluation scores and COVID-19 response performance	Nguyen et al. (2021)	JEE for health preparedness Emergency Response Capacity Tool (ERCT)	There is low agreement between JEE scores and COVID-19 response performance, with JEE scores often trending higher. The JEE indicator "Emergency Operations Center (EOC) operating procedures and plans" had the highest agreement and predicted probability with ERCT (62 percent), and the "capacity to activate emergency operations" had the lowest predicted probability (16 percent).
The National Health Security Preparedness Index (2021 release) Note: Not peer reviewed.	Mays et al. (2021)	NHSPI	COVID-19 deaths were significantly lower in communities with higher levels of health security as measured in the index when controlling for county population size, population density, percent aged 65 years or older, percent Black, percent Hispanic, percent below poverty level, percent under age 65 without health insurance, number of nursing home residents per capita, and social vulnerability rates measured in the Community Resiliency Index, and adjusting for clustering of counties within states.

GHS = Global Health Security; IHR = International Health Regulations; NHSPI = National Health Security Preparedness Index; SPAR = States Parties Self-Assessment Annual Report; TFAH = Trust for American Health index.

Appendix D. Technical Expert Panel Participants

Joseph A. Barbera, M.D., The George Washington University

Georges Benjamin, M.D., American Public Health Association

Paul Biddinger, M.D., Mass General Brigham

Laura Biesiadecki, National Association of County and City Health Officials

Jason Brown, Public Health Management Corporation

Jack Herrmann, M.S.Ed., American Red Cross

Richard Hunt, M.D., U.S. Department of Health and Human Services

Mark Keim, M.D., MBA, Fairfax County Health Department

Christine Kosmos, R.N., M.S., U.S. Centers for Disease Control and Prevention

James Lawler, M.D., M.P.H., University of Nebraska Medical Center

Beth Maldin Morgenthau, M.P.H., NYC Department of Health and Mental Hygiene

Jenna Mandel-Ricci, M.P.A., M.P.H., NYC Department of Health and Mental Hygiene

Glen Mays, Ph.D., Colorado School of Public Health

Ali Mokdad, Ph.D., University of Washington

Jennifer Nuzzo, Dr.PH., Brown University

Lisa J. Peterson, Association of State and Territorial Health Officials

Michael A. Stoto, Ph.D., Georgetown University

Eric Toner, M.D., Johns Hopkins Center for Health Security

Craig Vanderwagen, M.D., East West Protection, LLC

Michael Wargo, HCA Healthcare

Appendix E. Technical Expert Panel Agenda

A. Welcome and Stage Setting

B. Breakout Session 1: Current Measures

1. What is your experience with currently available measures and their strengths and weaknesses?
2. What did COVID-19 teach us about measures?
3. What important aspects of the literature on public health and health-care preparedness measures were not addressed in the environmental scan?

C. Breakout Session 2: Future Measures

1. What impact should measures have?
2. How should public health and health-care preparedness be measured?
3. What are common data sources that could be used for future measures?

D. Group Discussion: Framework Development

1. What current and future measures can inform the development of a framework?
2. Should the COVID-19 experience drive the development of public health and health-care preparedness measures?
3. Should the framework be based on threats, hazards, capabilities, or capacities?

E. Summary Remarks and Conclusion

Mathematica Inc.

Our employee-owners work nationwide and around the world.

Find us at **mathematica.org** and **edi-global.com**.

Mathematica®
Progress Together