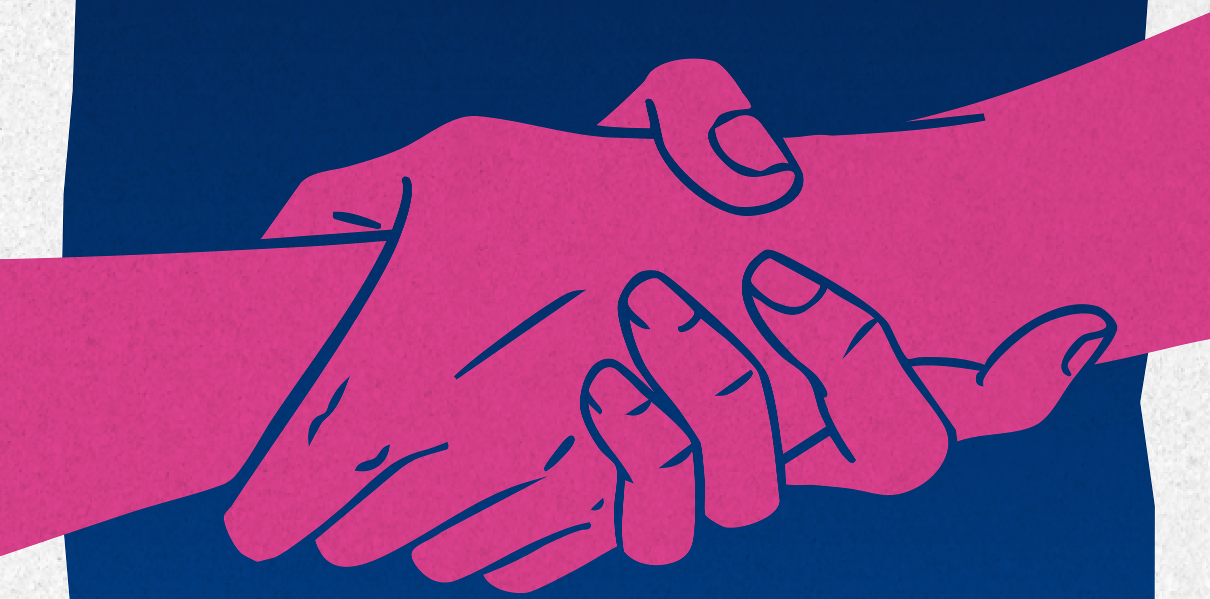
health systems resilience

Adapting Universality to a Changing World



Alessandro Jatobá • Paula de Castro-Nunes • Paulo Victor R. de Carvalho

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Centro Brasileiro de Estudos de Saúde (CEBES)

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Translated from the Portuguese by
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In 2016, he founded the ResiliSUS Laboratory at Fiocruz, which he has coordinated ever since. The laboratory's research promotes the integration of resilience as a core attribute to be considered in the design of public policies, management strategies, and health Technologies.

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Authors' Foreword

In the operations of universal health systems, the only constant is uncertainty. The global landscape of public health is defined by volatility. From pandemics and climate disasters to economic instability and social inequity, health systems worldwide face relentless pressure to adapt, absorb shocks, and transform. This book emerges as a vital response to these challenges. While deeply rooted in Brazil's pioneering experience with its Unified Health System (SUS), this book transcends borders, offering universal insights for policymakers, practitioners, and scholars committed to fortifying health systems against uncertainty.

Brazil's SUS is not merely a case study—it is a living laboratory for resilience. Born from a constitutional commitment to health as a universal right, the SUS grapples with contradictions familiar to many nations: vast territorial expanse, profound socioeconomic disparities, political turbulence, and resource constraints. Yet, within these tensions, SUS has cultivated remarkable adaptive capacities. It has weathered epidemics like Zika and COVID-19, pioneered community-based primary care through its Family Health Strategy, and built surveillance networks that blend digital innovation with grassroots participation. These are not theoretical ideals; they are tested practices forged in complexity.

This book's strength lies in its refusal to reduce resilience to disaster response alone. Instead, it reveals resilience as a daily practice — embedded in how health workers navigate variability, how communities co-produce care, and how governance structures balance standardization with flexibility. The SUS's narrative demonstrates that resilience is not a luxury reserved for high-resource settings but a necessity for any system striving to be equitable, comprehensive, and sustainable amid instability.

How can health leaders from such different countries like Norway to Nigeria, Canada to Cambodia, apply these lessons? The answer lies not in replicating blueprints, but in adapting principles. This book is not a manifesto for importing Brazilian models. It is an invitation to rethink resilience as a dynamic, context-sensitive process.

As climate change accelerates, political landscapes shift, and health threats evolve, the lessons from SUS's journey offer more than hope—they offer practical wisdom. Let this book inspire you to interrogate your system's brittleness, amplify its adaptive capacities, and build structures where resilience is not an aspiration, but a daily practice. The path forward demands courage, creativity, and collaboration. Brazil's story reminds us: resilience is built not only in turbulence, but also in tranquility.

We wish you a wonderful reading!

Part

Historical and Theoretical Foundations

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Chapter 1

Preamble

Resilient health systems must adjust to stress and challenges posed by chronic stressors and sudden demands, without compromising essential functions.

Over the past two decades, the rising frequency of emergencies has fostered a "culture of preparedness" within governments, leading to significant investments in risk management. Nevertheless, even in the absence of major crises, sustaining the preparedness of health systems remains a formidable challenge, given the growing and continuous complexity of the contexts in which they operate.

Ageing, poverty, war, migration, and climate change are among the many challenges that directly or indirectly impact population health. For instance, economic crises or conflicts in regions near high-income countries have triggered large waves of migration, often involving highly vulnerable populations. Sudden outbreaks of infectious diseases and other catastrophes are increasingly disrupting the functioning of health systems worldwide. The growing recurrence of unexpected events – varying in scale and impact – has underscored the urgent need to design system structures and develop management mechanisms capable of effectively responding to such disruptions.

The resilience of health systems – especially those centered on universality - has come under intense scrutiny in the wake of numerous recent crises, including natural disasters, terrorist attacks, industrial accidents, disease outbreaks, and the emergence of novel epidemics. Notable examples include the Fukushima nuclear disaster in Japan, the war in Ukraine, the Ebola outbreak in West Africa, and the COVID-19 pandemic caused by the novel coronavirus, SARS-CoV-2. In this context of heightened instability, health systems face increasing pressure to respond to urgent priorities across all levels of care and to adapt continuously to the demands imposed by emerging events.

Public health is particularly distinct in this regard. Take, for example, recent epidemics – most notably the COVID-19 pandemic – which struck the world suddenly and at a scale unprecedented in this generation. Comparisons can be drawn between the disruptions caused by the pandemic and other major challenges, such as ageing, poverty, war, migration, and climate change. Instabilities capable of triggering abrupt shifts in system functioning are far more common in health services, where unexpected events are part of everyday operations. In health care, such instability is not only more frequent but also more visible than in other organizational systems – such as aviation or industry – despite the latter's potential for rare but catastrophic failures.

Variability – often referred to as "performance variability" – is the ability of a system to change its behavior as contexts also change. Sources of variability can be endogenous, typically arising from the actions of individuals within the system, or exogenous, stemming from external factors that influence its operation. It is important to emphasize that variability, in any form, is not a synonymous with error or failure; rather, it is a normal and expected feature of complex organizations such as health systems. In fact, it is often *this variability that enables the system to continue functioning under pressure, particularly in situations of chronic stress.*

The ability of health systems to adapt, respond, absorb impacts, and fully recover is not limited to large-scale, highly disruptive events. Unexpected situations of varying intensity occur daily, often leading to sudden increases in demand for assistance. It is impossible to predict with precision what challenges may arise in a hospital setting or what unforeseen circumstances might disrupt the dynamics of a particular territory during a routine primary care visit, for example.

If resilience is defined as the capacity to adapt to the unexpected, then it must be cultivated continuously – not only in response to major crises or disasters. It is through everyday experiences and the development of a culture that supports resilience that systems can build the capabilities to anticipate, adapt, absorb, learn, and improve over time.

The permanent uncertainty about what may happen is a key factor underlying what resilience scholars identify as a central element: variability. It is in how systems manage variability that we can observe their potential for resilience – or, conversely, their vulnerability and brittleness.

The term brittleness is widely used in the literature as the conceptual opposite of resilience, although the two are not literal antonyms. In the field of Resilience Engineering, brittleness refers to a system property characterized by a tendency to degrade or fail when exposed to disturbances, reflecting a limited capacity to adapt under stress.

Public health organizations operate in inherently unstable environments shaped by a wide range of complex and interconnected factors – including social, economic, and technological pressures. It is therefore not surprising that these organizations are structured to adapt and capable of transforming their processes to meet current demands and anticipate future changes. When effectively managed, variability can serve as a driver for positive and continuous transformation in how the system functions.

Nevertheless, the dominant perspective holds that standardization and the use of protocols based on ideal or prescribed operating conditions are effective strategies for reducing the likelihood of extraordinary events and their consequences. This normative approach – aimed at eliminating variability – is not only resource-intensive but also limits the system's ability to adapt to unforeseen circumstances and to evolve through learning and positive transformation.

It is not feasible to anticipate all possible scenarios and adaptations when designing a system. However, complex public health services can be structured to remain dynamically flexible without compromising overall stability, allowing for adjustments that enhance manageability in unforeseen situations. The implementation of successive and continuous adjustments over time can help mitigate adverse outcomes and support the maintenance of control under challenging conditions.

In technical terms, "damping" refers to the gradual reduction of variability or the suppression of undesirable outcome deviations over time. While a system must be able to respond to changes and challenges, its responses should not result in loss of control over its essential functions. In health systems, these essential functions are defined and prioritized by health authorities to meet the needs of the population.

In systems management, organizations often operate on two distinct levels, commonly referred to as the "blunt end" and the "sharp end".

In public health system governance, the blunt end refers to the strategic layer, where policies and overarching operational guidelines are formulated and managed. In contrast, the sharp end refers to the operational layer – where health services are delivered and day-to-day management occurs.

It is evident that every organization requires a set of guidelines to govern its operations, processes, and planning. However, no matter how clearly and precisely these standards are defined, they ultimately reflect a prescribed course of action designed for anticipated scenarios. To foster resilience, systems must be designed to support adaptation – and these adaptations must be continuously analyzed over the system's lifecycle. Regardless of their intrinsic quality, protocols will inevitably fall short in capturing the full complexity of healthcare systems, given the impossibility of fully specifying the nuances of their real-world operations.

The notion that workers should avoid adapting their actions is both potentially dangerous and counterproductive. A review of recent disasters shows that, in many cases, workers followed existing protocols during emergencies based on their perception of the situation – often misaligned with what was actually unfolding. The demand for strict adherence to protocol may lead workers to apply standardized procedures to unexpected scenarios, impairing their ability to grasp and respond appropriately to the real conditions. In contrast to this traditional approach of restricting actions based on past disruptions, resilience is built through everyday practice –shaped by the adaptations that have sustained system functioning under routine conditions.

In all complex systems – including health systems – processes inevitably become interconnected, or coupled, in unforeseen ways, unexpectedly altering their information flows and even their structural configurations. These couplings often give rise to new structures designed to absorb disturbances, correct failures, and maintain the continuity of essential functions – even if that requires temporarily introducing functions not envisioned in the system's original design. From an overly normative perspective, such couplings might be viewed as threats to system safety. However, managing this variability on an ongoing basis creates valuable opportunities to strengthen resilient performance.

In the field of public health, resilience is understood as a concept – or set of concepts – that enables the analysis of a system's adaptive capacity to cope with, respond to, and adjust to stress, challenges, and unexpected demands. This applies regardless of when or at what scale these demands arise. Crucially, resilience involves maintaining the continuity of essential functions that must not be interrupted, even under conditions of extreme pressure.

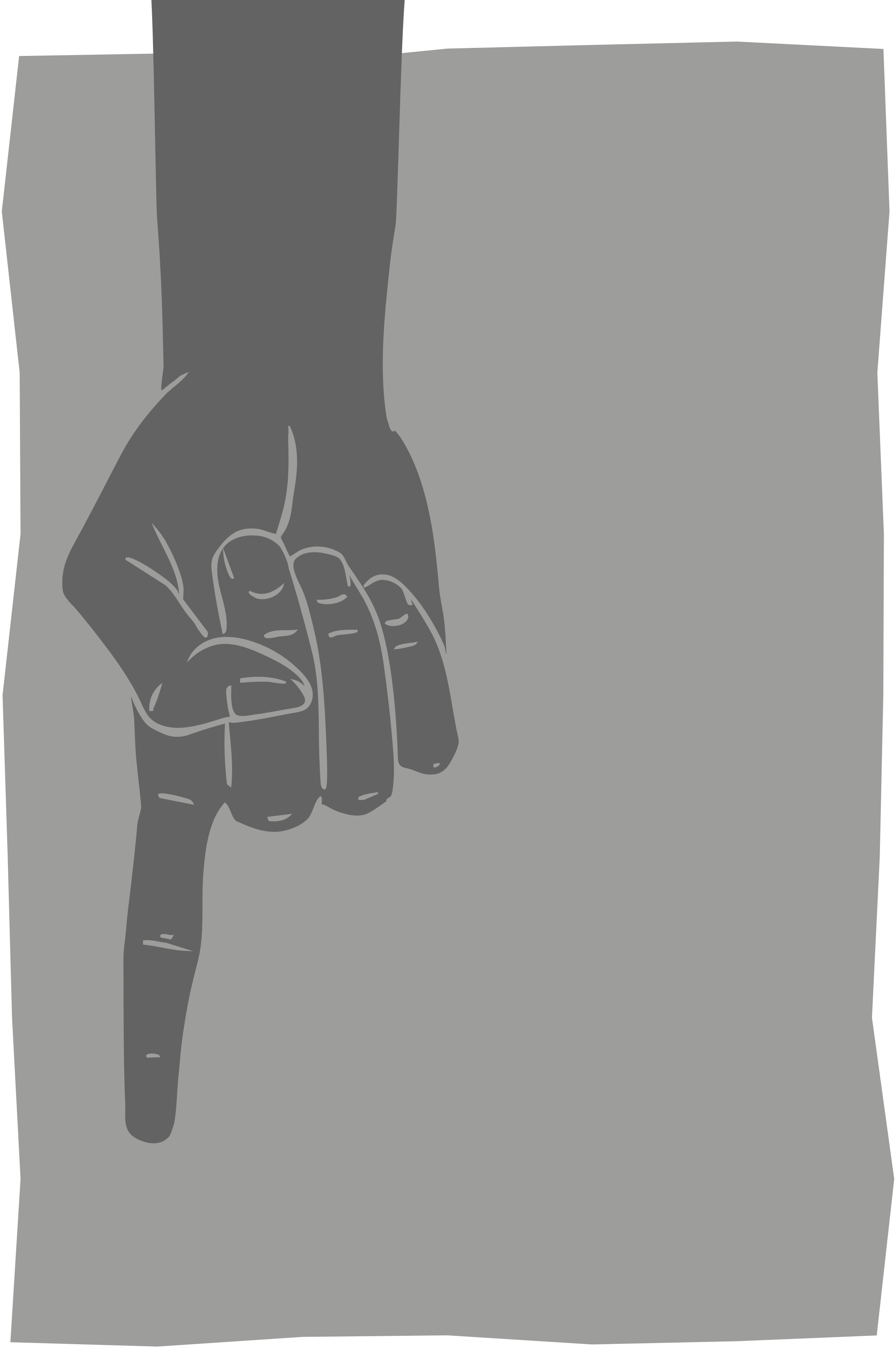
Given the lack of consensus in the literature on organizational resilience – both in theoretical frameworks and practical applications – the concept remains in ongoing development and, at times, carries some ambiguity. This dissonance, while inevitable, is also positive. It allows the concept to move beyond policy making and enables a more comprehensive understanding of system functioning across all levels and components.

There is considerable debate around how to manage system behavior in contexts of instability. Despite the critiques outlined above, the normative perspective remains dominant – one that assumes health work processes, including practices and protocols, must be predefined and standardized. While it is indeed necessary to establish standard procedures and protocols, equating variability with failure or error is problematic – especially in a field as dynamic as public health. It is unrealistic to assume that all work processes unfold in a predictable way. When the context shifts, people inevitably adapt their actions in response.

The Danish psychologist Erik Hollnagel, a pioneer in the field of Resilience Engineering, asserts in his seminal work on resilience that variability is never inherently negative or something to be avoided – particularly because, as he argues, it is impossible to fully define the conditions of a given context, especially in highly complex domains such as public health. According to Hollnagel, variability does not necessarily indicate system failure, just as changes in workers' behavior in response to variability are not inherently inappropriate. On the contrary, performance variability is essential for enabling systems to cope effectively with complexity (Hollnagel, 2006).

In short, variability is inevitable – and it can lead to both positive and negative outcomes. When it produces negative effects, it should be mitigated. However, when variability results in positive adaptations, it presents valuable opportunities to strengthen resilient behavior. Such innovations should be recognized and incorporated into the system's structure or management processes.

In Chapter 2, we will present a consistent and comprehensive framework for understanding the concept of resilience and its related principles within the context of the design and functioning of public health systems. As the definition of resilience evolves, our analysis will draw on the most current literature and recent experiences to highlight the key aspects and strategies that contribute to strengthening resilience in public health.



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Chapter 2

An Evolving Concept

Resilience has become a key concept for health systems, especially following the COVID-19 pandemic.

The term *resilience* has been used in various ways and across multiple contexts. Concepts such as resilience engineering, design for resilience, resilient systems, resilient functioning, resilient performance, and resilience assessment are among the most common uses. These terms are often used interchangeably, though not always in a consistent or coherent manner.

The literature on organizational resilience does not offer a single, fixed definition; however, most interpretations share a connection with the concept of human resilience, rooted in psychology. In this field, resilience refers to the ability of individuals to recover from shocks and return to stability after a disruptive event. Psychology has since expanded this understanding into a multidisciplinary perspective, framing resilience as an intrinsic capacity shaped by multiple skills – a broad human attribute for navigating complexity and adapting to change.

Since then, resilience in health systems has generally been understood as the ability of a health organization to recover after facing an unexpected disturbance. However, this definition is limited and does not fully capture the complexity involved in public health.

Beyond managing the number and frequency of disruptions that must be processed and absorbed to maintain service quality, these systems must also ensure that their essential functions remain uninterrupted – even while responding to unforeseen events.

Although described with slight variations across publications, the World Health Organization (WHO) defines the resilience of public health systems as the ability of health-related actors and functions to prepare for, respond to, mitigate, and collectively recover from disruptive events with public health implications. This includes maintaining the delivery of essential services while adapting and transform the system in a positive and sustainable way using the experiences obtained (World Health Organization, 2022).

> *A shock to a health system can be understood as a serious, extreme and sudden change that will impact the functioning of its services. The shock response follows a cycle consisting of (Thomas et al., 2020, p. 38):*
>
> - *Preparation: it is related to how vulnerable a system is to various disorders and how ready it is for the occurrence of an unexpected shock;*
> - *Start and alert: prompt identification of the beginning and nature of the shock;*
> - *Impact and management: the system absorbs the shock and, when necessary, adapts and transforms to ensure that its goals are still met;*
> - *Recovery and learning: return to a new type of normality, incorporating legacy components on the system and its performance.*

According to the WHO, a resilient health system features several key attributes, like: awareness of its own capabilities and vulnerabilities; the ability to mobilize and coordinate resources for effective risk management; self-regulation in responding to threats through evidence-based decision-making; the capacity to adapt as needed to endure adverse conditions; consistent and high-quality delivery of essential services in all contexts; and the ability to identify and apply lessons learned to drive improvement and transformation. Additionally, resilience requires integration across health security, system strengthening, and other health programs.

The European Comission Working Group on Health Systems Performance Assessment also offers a definition of resilience that aims to encompass key characteristics found across diverse frameworks – from Engineering to the Social Sciences. According to this group, health system resilience refers to the ability to proactively anticipate, absorb, and adapt to shocks, and to implement structural changes that sustain essential operations, enable a rapid return to optimal performance, and transform the system's structure and functions. This process ultimately strengthens the system and reduces its vulnerability to future shocks and disruptions.

While this definition shares expected overlaps with others, it also explicitly incorporates additional characteristics and capacities that address not only acute crises but also chronic structural stresses that evolve over time. This conceptualization positions resilience as an attribute that goes beyond merely withstanding the impact of external shocks on health service delivery. From this perspective, the likelihood of service interruption during unforeseen events is acknowledged, and the system's ability to mitigate impacts, implement corrective actions, adapt to new contexts, and learn from experience is viewed as surpassing the mere sum of its financial, material, and human resources – traditionally emphasized in health planning. To achieve this, health systems must cultivate a broad range of capabilities, including not only adaptive capacity, but also absorptive, transformative, and preventive capacities.

Absorptive capacity refers to the system's intrinsic ability to dampen the impact of a shock while continuing to deliver the same service levels – maintaining quantity, quality, and equity – using the same level of available resources. *Adaptive capacity* enables the system to sustain essential operations under extraordinary circumstances by delivering the same service levels through a different – and often more limited – combination of resources, requiring organizational adjustments. Transformative capacity is the system's ability to modify its structure and functioning in response to contextual changes in the operating environment. Lastly, *preventive capacity* involves anticipating potential shocks and creating the necessary conditions to minimize their future impact (European Commission, 2022).

These attributes are applicable across all phases of the emergency management cycle: prevention, preparedness, response, and recovery. This cycle – widely adopted by organizations involved in disaster management – highlights the essential role of health systems in coordinating emergency responses alongside other disciplines and sectors. For this reason, it is crucial to intentionally embed resilience into the design and development of health systems as a vital first line of defense against threats that impact not only public health but also multiple dimensions of the society, as evidenced during the COVID-19 pandemic.

The maintenance of stability and the development of shock absorption abilities are central themes in the field of Disaster Management. As a result, the concepts established in this domain are often the most widely referenced when attempting to define resilience in other areas. However, fostering resilient behavior goes beyond absorbing shocks – it requires mobilizing efforts to anticipate future failures. As variability increases the complexity of systems, it also demands increasingly innovative and adaptive responses.

The literature presents ongoing debates about whether it is desirable for a system to return to its original state after an unexpected disruption. If a system was already fragile prior to the shock, returning to its initial conditions may not be beneficial. In the case of health systems, which are inherently adaptive, a full return to the previous state is often unlikely. Shocks typically lead to shifts in both demand and supply, affecting communities, institutions, and organizational cultures. As a result, at least some level of permanent adjustment is usually necessary. This underscores the importance of developing transformative capacity as a fundamental component of resilience. Ultimately, resilient health systems should strive to ensure positive physical and mental health outcomes for all – including vulnerable and marginalized populations.

In Rio de Janeiro, for example, the response to COVID-19 required the suspension of elective procedures. To address the resulting backlog once the pandemic weakened, the Municipal Health Department (SMS) implemented several strategies, including the creation of the Super Centro Carioca de Saúde (Super Health Center of Rio de Janeiro), which began operating as a permanent service at the end of 2022. In Spain, to mitigate the spread of COVID-19 in long-term care settings, an interterritorial council expanded both the frequency and coverage of PCR testing in these facilities. These examples illustrate that resilience is not only about a health system's ability to absorb and adapt to shocks, but also about its capacity to transform and evolve – becoming more responsive to the complexities of its context.

Resilience has introduced a new perspective on how to adjust to shocks while maintaining essential services, compelling organizations to adapt to rapidly changing circumstances. The COVID-19 pandemic, the resurgence of infectious diseases, and other emerging and potential threats have further underscored the critical importance of building resilience into health systems.

Despite the significant rise in academic publications and increased attention from international health agencies following the COVID-19 pandemic, research and discussions on health system resilience still largely center on theoretical frameworks and foundational principles, while its operationalization stays challenging.

Beyond the COVID-19 pandemic, recent outbreaks of infectious diseases such as Ebola, Zika, H1N1, and more recently H5N1 have made resilience a central term in discussions about the functioning of health systems. Nevertheless, there is still no consensus on a single definition – nor is one likely to emerge in the near future. This lack of uniformity is both expected and beneficial, as resilience is grounded in a multidisciplinary foundation. Applying a narrow definition risk being reductionist and potentially problematic. While the term may serve as a useful shorthand for the ability to deliver quality care amid disruptions, in research it should retain a broader scope – encompassing diverse experiences and variable contexts, from infectious disease outbreaks to natural disasters, systemic crises, and periods of social or political instability.

While there is a substantial body of research on resilience across various domains – such as disaster management, accident analysis, and industrial system safety – applied research focused specifically on the development or strengthening of resilience within health systems remains limited. This represents a critical gap, as such research is essential for informing strategies aimed at enhancing the robustness and continuous improvement of health systems.

As seen during the COVID-19 pandemic, intense debates persist regarding the most effective, equitable, and efficient ways to prepare health systems for timely and consistent responses to unexpected events. These debates span a range of issues – from testing strategies and vaccination campaigns to the scope of lockdown measures, the regulation of medical products and devices, and the restructuring of service delivery. While responses must be tailored to specific contexts, the pandemic has made it clear that stakeholders increasingly seek evidence-based strategies, ideas, and plans to inform their decision-making.

The contemporary world functions as a network of interdependent systems that interact across multiple levels of society. In this context, the concept of resilience should contribute to a comprehensive and intersectoral understanding of health systems as highly adaptive and complex entities – enabling both the exploration of their potential and the identification of their vulnerabilities. However, resilience must always be complemented by other critical dimensions, such as development, sustainability, robustness, innovation, preparedness, and safety, as well as foundational principles of public health systems, including diversity, equity, and universality. While resilience offers a valuable and novel lens – often revealing otherwise hidden aspects of system functioning – it should not be viewed as the sole framework for assessing or guiding health system performance.

Considering *resilience* as an attribute that shapes the behavior of services naturally leads to diverse ways of framing it within the field of public health – highlighting its interdisciplinary nature. Accordingly, when addressing health systems, it is increasingly common to encounter expressions such as disaster resilience, community resilience, and organizational resilience. This reflects not only the layered complexity of health systems but also their intersectionality with broader political, economic, legal, and environmental systems, as well as with key sectors such as energy, transportation, agriculture, education, and climate. Recognizing these interconnections is essential for understanding resilience as a dynamic and integrative concept.

There is still no dominant paradigm for approaching – let alone assessing – the resilience of systems, particularly in the context of public health. Nonetheless, some more structured perspectives have begun to emerge. Among them, Resilience Engineering stands out as a relatively well-established approach for designing, maintaining, and evaluating systems that are inherently better equipped to operate resiliently. This perspective emphasizes the importance of developing both adequate physical infrastructure and robust management processes to enhance the system's capacity to adapt to unexpected events. However, aligning these two dimensions is not always feasible, as institutional capacity alone does not ensure resilient performance. Other approaches in the literature focus on resilience by analyzing the gap between how a system was designed or envisioned and how it actually operates. In cases where systems are already in place, efforts to promote resilience more often focus on management adaptations, as modifying system structure tends to be more complex and less flexible.

Having potential for resilience or being resilient?!

As previously discussed, operationalizing resilience in public health systems requires attention to a wide range of dimensions – from system design to the specifics of day-to-day operations. Some researchers conceptualize resilience as a skill – or a set of skills – that any system can develop in different scales. In this view, resilience manifests as a behavior or performance shaped by how the system is designed and managed.

This perspective allows for the assessment of a system's potential to behave resiliently. However, it also implies that the system's resilience cannot be definitively confirmed or denied; rather, it is an ongoing, dynamic capacity that evolves in response to the system's context and actions.

Moreover, the emergence of resilient performance entails a combination of structural characteristics – such as redundancies, operational margins, and slack resources – and managerial attributes, including workforce training, individual behaviors, and organizational culture. In other words, resilience depends on specific features that the system must actively build or cultivate. For this reason, the Resilience Engineering emphasizes the analysis of both the operation and articulation of a given system's structure. Assessing a system's potential for resilience requires understanding how it responds to and manages events, rather than merely examining its formal design.

For some authors, evidence that a system has behaved resiliently – either following a disturbance or over time – can be observed through a set of outcomes, primarily measured using quantitative indicators. Identifying variations in these results can offer some foundations for assessing resilience and, in some cases, for determining whether a system can be considered resilient. Furthermore, comparing the performance of similar systems – such as municipal health systems – can help identify gaps and guide necessary adjustments in the allocation and management of resources.

However, it is important to recognize that evaluating resilience solely based on outcomes significantly limits our understanding of a system's potential to behave resiliently. Performance in past situations does not necessarily indicate whether the system can respond effectively to future, and possibly different, challenges. Assessing resilience through historical results may limit the analysis to specific dimensions – such as preparedness or robustness in relation to certain types of events – which, although relevant, are not sufficient to ensure resilient performance across diverse and evolving contexts. In other words, evaluating resilience potential entails, to some extent, the ability to predict future conditions.

In addition, reducing the potential for resilience to a single aspect of human performance or worker behavior risks conflating it with other distinct factors. Not all adaptations can or should be judged through a simplistic positive/negative lens. Health workers routinely adapt their practices to manage variabilities that may affect system performance across diverse contexts – including economic, historical, socio-cultural, and political dimensions. These adaptations are often necessary to sustain service delivery and should be understood within the broader dynamics in which health systems operate.

What defines a resilient system is its ability to carry out positive adaptations continuously and with adequate resources – not merely its capacity to adapt. If all disruptions could be predicted, there would be no need for adaptive capacity, as standardized processes and protocols would suffice to address foreseeable situations. However, in the complex and variable contexts in which health systems operate, resilience depends on adaptive capacity, especially when change becomes indispensable to achieving system goals.

It is unreasonable to assess the resilience of health systems – deeply embedded in social, economic, political, and territorial arrangements – without accounting for the dynamics of these broader contexts. Reducing resilience to structural indicators, or even to indicators of human behavior alone, risks obscuring underlying vulnerabilities. Such an approach may fail to capture critical weaknesses in how health systems respond to disturbances, engage with users, manage care processes, and coordinate across different levels of service delivery, among other essential functions.

Recognizing *resilience* as a capacity – or a set of capacities – of health system does not eliminate the need to consider the circumstances in which the system operates. These conditions either enable or constrain the emergence of resilient characteristics. Analyzing resilience performance therefore requires a thorough understanding of how economic, historical, socio-cultural, and political contexts influence the functioning of health systems.

Complex sociotechnical systems self-organize and adapt to perturbations through variability – a phenomenon that, as will be discussed in Chapter 3 and revisit within a theoretical framework in Chapter 9, emerges continuously. To understand how these systems absorb, respond, adapt, or transform in the face of different types of disturbances, it is essential to analyze the attributes and structures that underpin their skills and capacities.

Health systems fall into this category, as they are shaped by both explicit and implicit rules, and by the diverse decisions and interactions of multiple actors – patients, health professionals, managers, policymakers, and private companies. The provision of care involves not only system management but also the social dynamics of communities, families, and service providers, all of which are key sources of resilient performance. These actors develop coping strategies and mobilize resources, both formally and informally. Such interactions are influenced by individual mindsets and interests, as well as by the physical infrastructure and dynamics of power within the context in which services must be delivered in a coordinated way. In this sense, workers, patients, and their communities form the foundation of resilient health systems.

Resilience, understood as a capacity, strengthens health systems by enabling them to deliver services in an equitable, efficient, responsive, and sustainable manner – both in routine operations and during unforeseen events. This perspective has been operationalized primarily through various analytical approaches, some of which will be seen in Part II.

As discussed in this chapter, the evolution of the concept of resilience opens new possibilities for its operationalization. When used in a complementary way, it provides a broader understanding of the dynamics and complexity of health systems such as the SUS (Brazil's Unified Health System). To develop truly adaptive health systems, it is essential to recognize and incorporate their interdependencies with other systems and contextual factors as key determinants of *resilience*.

Health systems should be understood as integral components of the broader productive structures of countries – shaping and being shaped by other sectors. The protection and promotion of people's health are intrinsically linked to each nation's political and social protection systems. This interconnectedness became especially evident during the COVID-19 pandemic, when the capacity of health systems to mobilize resources, coordinate responses, and address population needs had a profound impact on labor, the economy, and infrastructure worldwide. Overlooking this complexity risks producing solutions that are simplistic, unsustainable, costly, and ultimately ineffective.

The functioning of health systems relies on a network of intersectoral actions that can only be explored and enhanced through continuous, incremental improvements. As such, resilience must be cultivated on a daily basis – not solely in response to unexpected or major disruptions.

Therefore, evaluating how the health system both influences and is influenced by other sectors is essential to understanding variability and its impact on performance. A thorough analysis of the measures adopted to adapt system operations in response to contextual changes helps to identify resilient skills and capacities. This, in turn, enables the strengthening of the system's ability to respond to both expected and unexpected events, to learn from experience, and to monitor and anticipate risks and their potential effects.

Governance and resilience

The resilient performance of a system depends directly on its ability to scale and implement adaptations when necessary. To enable this, governance arrangements – as well as those of other sectors with which the system interacts – must allow room for change. These governance structures are central to driving resilient performance: they define priorities, facilitate coordination, and, most importantly, assign responsibility for decisions that shape the actions of all involved actors. Preparedness activation, strengthening robustness through resource mobilization, and adapting responses to disturbances are only feasible when decision-makers are equipped with the necessary authority. While governance contexts vary, understanding these arrangements is essential for designing the adaptive spaces that support resilient performance.

To achieve this, it is essential to establish appropriate structures and partnerships, along with clear and effective leadership capable of promoting and coordinating intersectoral actions – and, crucially, of recognizing the importance of resilience. It is important to distinguish between Leadership and Governance, as they are separate concepts, though deeply interconnected. Both are fundamental and cross-cutting elements for resilient performance. Only the combination of sound governance arrangements with competent leadership can ensure an appropriate and context-sensitive response to events of varying intensity and complexity.

Within the governance structure, clarity regarding hierarchy is essential – defining roles, responsibilities, and the management models used to organize the system's internal configuration and its interfaces with other sectors. Equally important are flexibility and coordination skills, as well as the ability to integrate the various components involved in the governance model. These elements are critical to ensuring an effective response during emergencies.

In the face of major events – such as climate-related disasters – different sectors must align around the adaptive capacity of the health system. Governance structures should be responsive to this intersectorality and flexible enough to accommodate the need for adaptation, as the broader management context directly influences the effectiveness and appropriateness of response actions.

In certain situations – such as infectious disease outbreaks – the leadership role of public health in responding to the event is clear. Regardless of governance arrangement, public health plays a crucial role in emergency preparedness and in leading mitigation and response efforts. This leadership is instrumental in shaping a culture of resilience within the system.

This form of leadership is dynamic, evolving as organizations interact and gain a deeper understanding of one another's contexts. The skills of leaders are activated and applied as the disruption unfolds. Therefore, it is essential to develop planning capacities and support structures that enable organizations to recognize and mobilize the skills required in response to unexpected events. In parallel, governance structures must also evolve, allowing leaders to take on new roles in planning and preparedness for future disruptions.

The relationship between governance and resilience is marked by important particularities. Variations in power distribution, leadership dynamics, and governance contexts all influence a system's capacity to adapt. While resilience can enhance governance by improving risk management and response processes, system transformations bring additional complexity. As systems evolve, it becomes increasingly important to understand how these changes feed back into governance structures, as this will directly affect the system's ongoing ability to adapt to future shocks.

To understand how a health system adapts to operate under stress – and the processes and behaviors that support this adaptation – it is essential to draw on research methods from both engineering and the social sciences. Beyond quantitative variables, assessing the potential for resilient performance requires a deep analysis of qualitative aspects related to system functioning.

Research on the resilience of health systems must also examine their development, legal frameworks, and evolution over time, as these elements are key to revealing system dynamics. Analyzing this evolution is essential to understanding the factors and processes that contribute to resilient performance. It also sheds light on the short- and long-term consequences within adaptive spaces and helps identify the elements that strengthen absorptive, preventive, and transformative capacities.

According to WHO, health governance should ensure the presence of policies and strategic frameworks supported by effective oversight, coalition building, regulation, system design, and transparency. Three main categories of stakeholders shape the health system and its governance:

- The State;
- Public and private health service providers;
- Citizens (patients).

Under the 2030 Agenda for Sustainable Development Goals (United Nations, 2017), the World Health Organization (WHO) supports countries in strengthening the effective governance of their health systems, with a focus on enhancing government capacity. WHO's efforts aim to empower key actors and improve the responsiveness of health systems through actions focused on:

- Support the development of national health policies and strategies that enable the effective implementation of Primary Health Care (PHC) for universal coverage and access to services, including health safety;
- Strengthen and reform health institutions, laws and regulations, including legal frameworks for universality of access, quality of care and protection from financial risks;
- Establish social participation mechanisms, promote the empowerment of people and communities in the supervision and representation of citizens in decision-making processes, with gender equality;
- Collaborate with parliamentarians to promote legislation and financing of health actions;
- Promote multi-sectoral and inclusive collaboration among all stakeholders in a responsible and transparent manner, with specific efforts to include the private sector in favor of universality;
- Develop standards for the monitoring of universal health coverage and access policies and strategies; strengthen national monitoring of policy implementation and ensure the establishment of legal frameworks that promote, enforce and monitor equity and human rights;
- Articulate harmoniously and adequately finance health action plans, aiming at health safety.

The COVID-19 pandemic not only exposed the limitations of national health systems but also highlighted the risks to which they are vulnerable – such as structural or financial collapse and the illness of healthcare workers. It revealed significant deficiencies in coordination across sectors within institutional and governmental governance arrangements. Moreover, the pandemic underscored the challenge of rapidly expanding health services while maintaining routine care delivery. The critical importance of cross-sector collaboration also became evident, as seen in the urgent need for mass testing, disruptions in supply chains (e.g., oxygen and personal protective equipment), and the difficulties in rolling out vaccination programs amid denialism promoted by some political leaders worldwide.

As noted at the beginning of this chapter, challenges are intensifying, and disruptive events are becoming increasingly frequent. Any conceptual framework aimed at strengthening the resilience of health systems must therefore be dynamic, capable of capturing the complexity and constant evolution of the contexts in which these systems operate. A meaningful approach to resilience must be grounded in an understanding of each system's uniqueness, recognizing the diversity of its elements, capacities, and capabilities. It is essential to acknowledge that the definition and application of resilience will always be shaped by the specific context in which it is used.

The conceptualization of resilience should not be rigid, prescriptive, or definitive. On the contrary, it must be broad and flexible, enabling the development of theoretical models that acknowledge complexity and variability. Such models should be capable of accounting for cumulative disruptions and chronic stresses, while also fostering the ability to learn from experience, monitor risks, and anticipate future failures.

Summary

In this chapter, we have seen that the essence of resilience – adapting procedures, recovering from shocks, and returning to a stable condition – can be understood and operationalized in multiple ways, even within the field of public health. Diverse definitions have enabled a wide range of research and practical applications in health systems across the globe. Nonetheless, the conceptualization of resilience most frequently adopted by organizations aligns with that proposed by the United Nations for disaster and climate risk management, as outlined in the Hyogo Framework for Action (United Nations, 2017), originally published in 2005. This alignment was particularly evident in the global response to the COVID-19 pandemic, and we will explore further examples in Chapter 16, which discusses the resilience strategies developed by the European Commission.

On the other hand, Resilience Engineering offers a more structured theoretical and methodological framework, conceptualizing resilience as an attribute that is developed and exercised in the everyday functioning of systems. This approach has gained considerable traction among public health scholars and presents significant opportunities for both research and practical application in the field.

Finally, we also explored resilience as a tool for strengthening the governance of health systems – one that goes beyond merely responding to shocks and disasters or enhancing system performance. It enables the incorporation of new concepts and approaches that support the development of preventive, absorptive, adaptive, and transformative capacities.

In the next chapter, we will explore the importance of resilience as an essential attribute in the conception, design, and operation of health systems. This discussion is critical, as even in systems that struggle to maintain minimum standards of care quality, the focus on building the potential for resilient performance must not be overlooked.

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Chapter 3

Resilient Systems and Services

Resilience is fundamental for enabling public health systems to respond to challenges while functioning effectively in a universal, comprehensive and equitable manner.

Why, after all, is resilience so important to public health? This question can be better understood when placed within the historical context of the twentieth century – a period marked by significant shifts in how Health was conceptualized, leading to the contemporary understanding we have today. A pivotal moment in this transformation was the publication of the Flexner Report in 1910 by Abraham Flexner (1866–1959). This report laid the foundation for the biomedical model by establishing scientific medicine as the dominant framework – one centered on physiology and disease.

The concepts disseminated by the Flexner Report triggered a series of consequences – from the closure of medical schools that failed to conform to the proposed model to the widespread adoption of a culture in which health came to be understood merely as the absence of disease. Although this notion still persists, it has fortunately been losing ground. One of the report's most significant conceptual impacts was the separation of individual suffering from the broader social context in which it occurs, leading to the fragmentation of care (Flexner, 1910).

Although the predominantly biomedical definition of health continues to prevail in the minds of many, the Flexner Report was met with questions and criticism even at the time of its publication. Several authors challenged its propositions, offering alternative perspectives. As early as 1920, the American bacteriologist Charles-Edward Amory Winslow (1877–1957) advanced a more modern and comprehensive definition of public health, stating that:

> *Public health is the science and art of preventing disease, prolonging life and promoting physical health through organized community efforts for the sanitation of the environment, the control of community infections, the education of the individual in principles of personal hygiene, the organization of medical and nursing services for early diagnosis and preventive treatment, and the development of the social machine that will guarantee to each individual in the community an adequate standard of living for the maintenance of health.* (Winslow, 1920, p. 30)

This concept offered a more comprehensive perspective, emphasizing the responsibility of health authorities to ensure the right of access to health programs and services, prevent disease, and promote health at both individual and collective levels. It also broadened the previously narrow understanding of resources essential to health, incorporating private goods that have a significant impact on public health.

From the 1970s onward, criticism of the biomedical model intensified, driven not only by concerns related to care organization but also by issues surrounding the financing of health systems. Debates on organizational models based on regionalized networks, team-based care, and multi-professional approaches gained momentum – broadening the concept of health well beyond its clinical dimensions. This expanded understanding significantly increased the complexity of health systems by deepening their interconnections and interactions, thereby amplifying their potential for variability. By incorporating dimensions such as general well-being and a holistic view of individuals within their communities, the evolving notion of health made the pursuit of resilient performance in this system of systems not only relevant, but essential – a concept that will be explored in more detail later.

In Brazil, by contrast, discussions around health system development have, from the outset, prioritized vulnerable populations. Core principles included regionalization, universal access, large-scale immunization campaigns, and the organization of comprehensive care networks. Moreover, the Brazilian health movement has drawn on the experience of other key initiatives, such as the Anti-Asylum Movement, the response to the HIV/AIDS epidemic, and efforts to combat hunger and extreme poverty, among others.

Several core concepts that continue to underpin Brazil's Unified Health System (SUS) were developed during this period, including health promotion, disease prevention, medicines distribution programs, the management of chronic conditions and complex cases, and the monitoring of health risk factors. Primary Health Care (PHC) also began to take on a more prominent role, with initiatives at this level gaining traction – most notably the Community Health Workers Programme (PACS), which laid the foundation for the Family Health Strategy (ESF) in the early 1990s. In the years that followed, particularly from the mid-1990s to the early 2000s, supplementary health care began to undergo increased regulation. During this time, the concept of health as a right of the people and a duty of the State – sustainable and responsive to population needs – continued to gain ground.

This period is also marked by important advances in foundational discussions on integrality and equity – principles that are not only essential to the SUS, but also pose ongoing challenges given the historical inequalities within the Brazilian population. The notion of care expanded beyond the delivery of biomedical or clinical actions to encompass the fight against violence, the promotion of self-care, and the respect for individual uniqueness. The concept of the patient also evolved, giving way to a more comprehensive notion: the "user" as an active participant in the co-production of care. As such, the performance of services is influenced not only by institutional structures, but also by the behaviors of users within the territories they inhabit. Due to this diversity, users themselves become sources of variability – and thus key elements in understanding SUS's potential for resilience.

The SUS was conceived to confront obstacles that – though not yet fully overcome – aptly illustrate the degree of variability inherent in the monumental task of establishing a universal, comprehensive, and equitable health system within a context marked by deep social inequality, vast territorial expanse, and a highly diverse population. It is important to recognize that variability is intrinsic to complexity and does not inherently produce negative outcomes. In this regard, the SUS has, since its inception, developed mechanisms – often tacitly – that support resilient performance.

Conceived as a system grounded in solidarity, the SUS approaches users holistically, considering their broader life context. Health actions are therefore directed not only toward individuals, but also toward their communities. To achieve this, the system was implemented through a regionalized and decentralized model, organized around the specific needs of defined territories and their populations. Decision-making authority and responsibility for implementing health actions are delegated to the local level, employing strategies that are appropriate to the realities of the populations being served.

Rodriguez Neto (1998, p. 7) explains the adequacy of the expression "unified system" to name SUS. For him, SUS is a unique system because:

> *(...) it is formed by several institutions of the three levels of government (Union, States and Municipalities), and by the contracted and agreed private sector, as if they were the same body. Thus, the private service, when contracted by the SUS, must act as if it were public, using the same standards as the public service.*

The author emphasizes the concept of a system as the arrangement of elements and components within an articulated structure aimed at achieving specific objectives. With regard to the term 'unified', Rodriguez Neto (1998) describes it as a coordinated set of elements that adhere to "the same doctrine, the same philosophy of action throughout the national territory". We will explore the characterization of the SUS as a sociotechnical system in more depth later, drawing on classical theories. For now, this definition already reflects how SUS services are operationalized and illustrates the implementation of a system capable of resilient performance.

In addition to Brazil, several other countries maintain so-called universal health systems. Notable examples include the British National Health Service (NHS), as well as the systems in Cuba, Uruguay, France, Portugal, Sweden, Australia, Italy, and Canada. However, the principle of universality in these countries is not as comprehensive as the concept enshrined in the Brazilian Constitution for the SUS.

This is partly due to health sector reforms associated with the expansion of the liberal economic model throughout the twentieth century, which often curtailed the scope of public services.

According to the renowned public health scholar Jairnilson Paim, the reforms implemented in various countries adhering to the welfare state model have significantly impacted their health systems, paving the way for the concept of Universal Health Coverage (UHC) as a counterpoint to universal access – typically the objective of public health systems (Paim, 2020). The concept of UHC, strongly influenced by the Rockefeller Foundation and the World Bank, re-emerged roughly a decade later, in 2015, as one of the Sustainable Development Goals (SDGs) under the 2030 Agenda.

Paim also notes that the past decade has witnessed intense debate around differing conceptions of universality, particularly regarding the linkage between the right to health and individuals' purchasing power or their position within the labor market. Universal Health Coverage (UHC) seeks to reconcile universal health systems with pro-market reforms, leading to what Paim describes as a shift toward "market universality". In contrast, universality is a foundational principle of the SUS, guaranteeing that all individuals – without exception, and regardless of gender, race, occupation, or any other personal or social characteristic – have the right to access any public health service available in Brazilian territory, without the need for payment. The State holds the responsibility for ensuring the fulfillment of this right.

In the 2030 Agenda, the Sustainable Development Goal (SDG) 3 (Health and Well-being) aims to achieve universal health coverage, including protection against financial risks, access to essential quality health services and access to safe, *effective, quality and accessible vaccines and essential medicines for all (UN, 2017). Although in some excerpts the document also mentions universal access to health, the emphasis given to universal coverage immediately refers to the ambiguity of the UHC concept.*

As we have seen, the terms “access to health” and “health coverage”, while complementary, have distinctly different meanings. According to the Pan American Health Organization (PAHO), access to health refers to the ability to obtain comprehensive, appropriate, timely, and high-quality health services when needed. Expanding this concept to encompass universality involves addressing and overcoming geographic, economic, sociocultural, organizational, and gender-related barriers that may prevent individuals from equitably utilizing health services.

On the other hand, health coverage refers to the system’s capacity to mobilize infrastructure, human resources, technologies, medicines, and financing to meet the needs of the population. Achieving universal coverage, therefore, entails overcoming the systemic barriers that hinder equitable reach across the entire population. The concepts of access and coverage are complementary – both are essential to ensure the health and well-being of all. This requires the formulation and implementation of policies and actions that adopt a multisectoral approach to address the social determinants of health. In this sense, universal health encompasses both access and coverage.

The concept of Universal Health Coverage (UHC) has been interpreted ambiguously, leading to varying understandings among health authorities. In general, as Giovanella *et al.* (2018) point out, UHC tends to promote increased private sector involvement in health financing, thereby facilitating the expansion of the private market at the expense of public sector participation. This interpretation aligns with the critique put forward by Jairnilson Paim.

Access to SUS services is governed by the principle of universality and must also be equitable. While the term *equity* is often used to refer to the equal distribution of rights, in the realm of social rights it is essential to consider individual specificities. This approach goes beyond the notion of equality to avoid producing injustices. When we affirm that every citizen has an equal right to access SUS services, we mean that all individuals have the same right to care, but with attention to their particular needs. Equity, therefore, is a fundamental principle aimed at ensuring justice and full citizenship, as a means of addressing inequalities and safeguarding the well-being of all.

Equity definitively links the right to health with the concept of social justice. Sarah Escorel distinguishes equity from equality by arguing that equity refers to the relationships shaped by the accumulation of power within a social class, whereas equality is the potential outcome of equity. In other words, equity and inequity provide the foundation for understanding equality and inequality. As such, the principle of equity introduces the recognition of difference into the public sphere of citizenship, where equality remains a central value (Escorel, 2001).

Professor Escorel's work is notable for framing equity as a central dilemma that must be addressed for the SUS to become truly democratic. She emphasizes the importance of distinguishing between equity and equality, noting that any discussion of equity inevitably involves a value judgment shaped by ongoing social struggles over differing standards of citizenship. This perspective aligns closely with the mission of the SUS, captured in one of the most emblematic statements by Sergio Arouca (1941–2003), who described the SUS as "a civilizing process”. In other words, overcoming inequalities is inseparable from the development of an equitable health system.

In addition to being equitable, care within SUS services must be comprehensive, ensuring that users receive attention across all levels of care, regardless of the complexity of the procedures – from preventive to curative interventions. This principle affirms that users should be approached holistically, both as individuals and as members of a collective.

The introduction of integrality as an essential principle of SUS is crucial to bridging the gaps between preventive and curative care, as well as between individual and collective approaches to care. It provides a framework for organizing healthcare in a way that aligns with the specific realities of the Brazilian context.

Despite this, integrality remains one of the key challenges in the operationalization of SUS. Given Brazil’s diversity, this concept must take shape in multiple ways and cannot be reduced to technical actions rooted solely in biomedical knowledge. As the public health scholar José Ricardo de Mesquita Ayres (2001, p. 69) points out, “technical success is limited to how to do it, not including what to do”. The challenge of achieving integrality goes beyond the application of existing technical resources and calls for the continuous, context-sensitive development of knowledge and practices that are aligned with real needs. It surpasses technical success understood merely as effective execution.

The organization of comprehensive health services is based on a defined population. These services encompass both population-based and individual interventions aimed at health promotion, diagnosis, treatment, palliative care, and rehabilitation, as well as the provision of short-, medium-, and long-term care. The delivery of individual and collective health services influences – and is influenced by – the social, economic, cultural, and political conditions that shape the health of the population.

In this perspective, public health services can be classified by five levels of intervention:

- On the social determinants of health (e.g. poverty reduction and improvements in education);
- On contextual factors that put health at risk (e.g. access to drinking water and safe roads);
- Actions with long-term benefits (e.g., access to immunization and screening services);
- Individual (or personal) care;
- Health education to promote change in behavior (e.g. encouraging physical activity and adopting a healthy diet).

According to the Pan American Health Organization (PAHO), interventions at the first two levels have the greatest potential to improve population health, but they require stronger political commitment, as they entail broader social transformation. In contrast, the remaining three levels focus on individual care, which can still generate population-level impact – provided that quality and universal access are ensured.

In the SUS, comprehensiveness is a cornerstone of resilience – understood as the construction of a collective and continuous practice that does not rely on ideal conditions, but instead responds to the local reality. As a guiding principle of the SUS, comprehensiveness involves the application of rules and disciplines beyond the health field, generating variability in work processes. Many of these variabilities produce negative effects and must therefore be mitigated. Others, however, may yield positive outcomes, and the system must be capable of integrating them in order to foster resilient behavior.

Building on these theoretical foundations, it is essential that the SUS continuously fosters its inherent potential for resilience – by incorporating evidence-based concepts and frameworks, improving existing mechanisms, and developing new ones to enhance the adaptive capacity of its services in response to the evolving conditions of territories and populations.

At this stage, it is not merely a matter of aligning the essential principles of the SUS with a theoretical-methodological framework for resilience analysis. Rather, the operationalization of health services according to these principles creates an environment conducive to resilient performance. Conversely, current challenges must be addressed to prevent the emergence of new vulnerabilities.

Reorientation of the care model towards resilient performance

Jairnilson Paim, in his book *What is the SUS* (Paim, 2009), describes the Brazilian health system through the lens of the diversity of services, policies, and ideologies that intersect within it, while also addressing its key challenges and contradictions. Although the book's title is self-explanatory, one of its main contributions lies in emphasizing the difficulty of fitting the SUS into classical definitions of systems, particularly those rooted in the theoretical framework of business administration. This includes the General Systems Theory proposed by Von Bertalanffy (1972), a characterization we will explore in greater detail later.

To examine the potential for resilient performance in health systems, it is essential to establish a precise definition of what constitutes a health system and, more importantly, to understand how its various subsystems interact – even as these dynamics evolve over time, much like the very concept of resilience. It is common to refer to national or local health policies as systems; however, these policies operate at a higher level of abstraction. They represent ideas, concepts, intentions, and ideals that guide the design and influence the performance of related subsystems, but they do not, in themselves, produce the immediate and tangible outcomes that users expect from health services.

To assess the potential of the SUS for resilient performance, it is essential to understand how policies and the various subsystems within the health sector interact. However, this characterization is far from straightforward. As Rodriguez Neto points out in the text cited at the beginning of this chapter, although the SUS includes the term system in its name, it is, in fact, a system of systems, whose scope of influence encompasses political and cultural dimensions that extend far beyond the realm of practical actions.

In this regard, Paim notes that the term *system* can have multiple meanings, but defines a health system as “the set of agencies and agents whose primary objective is to ensure the health of individuals and populations”. He also makes an important distinction between health systems and health service systems, although the two expressions are often used interchangeably in common discourse. According to Paim, the set of agents and agencies that comprise the health service system is limited to services themselves – that is, to the subset of actions focused on disease prevention, health promotion, protection, recovery, and rehabilitation. This definition excludes sectors such as the pharmaceutical industry and the medical-hospital equipment industry, which belong to the broader health sector but are not considered part of the service system.

What Paim means is that, although health services play a central role, the health status of the Brazilian population does not depend solely on them. Numerous other actions that influence health are carried out outside the health service subsystem – such as those undertaken by schools, the judiciary, media organizations, industries, and research institutes. From this perspective, the health service system is just one of several subsystems within the broader health system. It includes only those actors directly involved in the provision of care. In contrast, the health system encompasses all interrelated agents and agencies, whether public or private, whose focus is on the production and promotion of health at both the individual and population levels.

By establishing the State's obligation to guarantee health, the Brazilian Constitution also implicates economic and social policies that directly or indirectly affect the health of the population – such as reducing risks, addressing violence, and protecting against environmental hazards. The SUS Organic Law itself highlights the importance of "determining and conditioning factors, including food, housing, basic sanitation, the environment, work, income, education, transportation, leisure, and access to essential goods and services" (Brasil, 1990) for the health and well-being of individuals. Based on this expanded concept of health, as adopted in Brazil, improving population health necessarily requires action on the social determinants of living conditions – which, in turn, implies engaging with the country's broader economic and political structures.

It is easier to visualize the elements or subsystems of the SUS – or of any other system – that support the potential for resilient performance when we shift our focus to the sharp end, observing how the service delivery system adapts to the shocks it faces. For instance, it is more straightforward to describe how the network of primary health care units was reorganized to respond to COVID-19 than to assess whether the SUS, as a whole, demonstrated resilient behavior in the face of the pandemic.

Resilience develops from the conditions that the system provides for health workers to acquire the capabilities necessary to formulate adaptation strategies. Therefore, the closer our focus is to health work across the different levels of the system, the more visible the potential for resilient performance becomes. This proximity can serve as a valuable starting point for analyzing a health system's resilience potential – an analysis that should ultimately extend to examining how this evidence relates to dynamics at the blunt end of the system.

At the sharp end, the ability of workers to collaborate in managing extraordinary situations is also a key factor in determining the resilience or fragility of services. Inadequate or insufficient collaboration within the team can lead to serious consequences, including loss of life. Core attributes of effective teams – such as trust, social support, quality of interpersonal relationships, collaborative leadership, and cohesion – have a significant impact on resilient performance.

At the blunt end, the ability to respond effectively to demands and stressors – including natural disasters and large-scale emergencies – is directly related to how the health system has been designed. For instance, resilient performance depends on whether the system's design includes specifications that enable, or at least facilitate, the maintenance of quality care during shocks, crises, or disasters.

A recent study analyzing the work of community health agents during domiciliary visits identified adaptations to visit protocols in response to management-imposed targets and constraints in the working environment – particularly in accessing families in vulnerable communities (Jatobá *et al.*, 2018). In this case, it is important to emphasize that the adaptations made by workers to meet managerial goals did not result in improved care; quite the opposite occurred. Another study examined the challenges faced by SAMU-192 emergency medical teams in the Amazon region in 2020, at the height of the COVID-19 pandemic, using a model developed prior to the crisis (Arcuri *et al.*, 2022). It revealed, for instance, that the lack of collaboration from reception staff – an unscheduled yet frequent practice before the pandemic – significantly hampered the work of first responders.

Both studies highlight aspects of resilience and fragility in domiciliary visits and in urgent and emergency care for vulnerable populations. These functions of the SUS are influenced by challenges such as demographic and epidemiological transitions, as well as crises in governance arrangements – including funding constraints and adaptations to prevailing social ideologies regarding public policy. These findings illustrate how the organization of the health system – the blunt end – produces effects on the sharp end, leading to explicit manifestations of either resilience or fragility in service delivery.

> *Health care model, according to Jairnilson Paim (2009), is the form of organization of relationships between health professionals and users, mediated by technologies used in the work process, whose purpose is to intervene on damages, risks and health needs. The current model of health care proposes several actions of promotion, protection, recovery and rehabilitation, through care services and health surveillance, offered to the individual, his family and the community.*

Other aspects, such as vulnerability and the social determinants of health, must also be considered in research on the resilience potential of SUS services. Resilience is essential not only for the long-term sustainability of the system but also for reinforcing its sociotechnical nature – ensuring the capacity to mobilize personnel, teams, organizations, support systems, financing, and services to meet the needs of people regardless of their social, economic, or cultural backgrounds. An adequate SUS response to unexpected events therefore depends on collaboration between the sharp and blunt ends of the system, forming a care model that fosters the capacity to anticipate future disruptions, learn from experience, and continuously monitor the organizational environment.

The SUS represents a profound reorientation of the care model, breaking definitively with the Flexnerian paradigm – not only from clinical and legal perspectives, but also operationally – by adopting innovative approaches to the delivery of health services that ensure universal, comprehensive, and equitable access for the population. The system's foundational rules for structuring and functioning are notably distinctive, encompassing its doctrine and core principles regarding the rights, duties, and responsibilities of citizens and the State, as well as the organization of public and private health services across different levels of care – including hospital, outpatient, specialized procedures, and diagnostic support.

To this end, the SUS integrates key organizational principles – decentralization, regionalization, hierarchization, resoluteness, and complementarity with the private sector – into its core principles of universality, comprehensiveness, and equity. This approach transcends strictly technical or logical models of system design. As a comprehensive public policy enshrined in Brazilian legislation, the SUS enables the implementation of diverse subsystems. In fact, the Organic Health Law stipulates that the SUS must be structured in a decentralized manner. Each locality, therefore, organizes its own service delivery system according to general guidelines, while adapting to the specific characteristics of its territory. It is at the local level that the SUS most clearly materializes as a sociotechnical system, aligning with the theoretical foundations commonly recognized in the field of traditional management.

Eugênio Vilaça Mendes defines Health Care Networks (HCNs) as "polyarchic organizations of sets of health services, linked to each other by a *single mission, common objectives, and cooperative and interdependent action, which allow for the provision of continuous and comprehensive care to a given population, coordinated by Primary Health Care (PHC) and delivered at the right time, in the right place, at the right cost, with the right quality, in a humanized way, and with both health and economic responsibilities for that population" (Mendes, 2010, p. 2300). This definition emphasizes the collaborative nature of network formation, where active and accessible coordination mechanisms, situational awareness, and reliable communication between actors are essential – alongside shared and accessible collective knowledge.*

Health systems are structures intrinsically embedded within the social fabric and, as such, are inherently multidimensional – intersecting environmental, epidemiological, strategic, educational, economic, and cultural domains, among others. Coordinating services to address this multidimensionality is a highly complex task. Consequently, fragmented models, organized around isolated points of care and primarily focused on acute conditions, still prevail. According to Eugênio Vilaça Mendes, a leading scholar on Health Care Networks (HCNs), such fragmentation prevents the system from delivering comprehensive and continuous care (Mendes, 2010).

According to this author, fragmentation increases the separation between levels of care, distancing, for instance, Primary Health Care (PHC) from secondary and tertiary services. In contrast, Health Care Networks (HCNs) are organized through coordinated and geographically defined points of care, which promote comprehensiveness and continuity. Although complex, network-based organization also enhances resilience by optimizing resources, facilitating users' access to different services, and enabling the adaptation of care pathways to local realities. These networks are continuously reorganized according to population needs and incorporate specific experiences shaped by their contexts. Mendes characterizes HCNs as living organisms that survive by adapting to their environment, integrating innovations throughout a dynamic life cycle marked by variability. While this dynamism presents challenges, it is essential for the effective functioning of health actions. Nevertheless, implementing HCNs within the SUS remains a significant challenge for both users and health professionals, who operate within a culture still largely shaped by fragmented care models.

As an instrument with the potential to foster resilience, the management of Health Care Networks (HCNs) must be flexible in the use of existing resources to address health problems. While maintaining coherence across the set of services and cohesion among the network's constituent elements, HCNs must be organized in a way that ensures adaptability to the inherent instability and specific needs of each territory.

Collaboration is a key element for resilient performance, particularly in enhancing organizational efficiency and learning processes. Collaborative Health Care Networks (HCNs) can strengthen system readiness, response, and recovery across different levels, while also engaging other actors involved in care delivery, emergency management, government, and even the private sector. Within user care flows across HCNs, multiple groups operate together, with a shared understanding of their roles and of each other's strengths and limitations. When this collaborative structure is actively supported, it plays a significant role in promoting resilient performance.

Health Care Networks (HCNs) play a crucial role in mobilizing the knowledge required for effective system performance during crises, thereby strengthening adaptive capacity. Knowledge sharing – whether formal or informal – is always a key component of organizational learning. The concept of networked systems supports the integration of diverse skills and resources, which is especially important in contexts where variability leads to unpredictable system behavior.

On the other hand, Health Care Networks (HCNs) are also sources of non-linearity and must adopt strategies to dampen variabilities that may lead to negative outcomes. When properly understood, both positive and negative variabilities can offer valuable insights for system improvement. Users and workers within HCNs are constantly changing as a result of their interactions and accumulated experiences, and the networks themselves evolve over time. This ever-changing profile reinforces the dynamic nature of the health system and must be considered in its planning and management.

Summary

In this chapter, we begin with the more rigid and protocol-oriented view of health systems shaped by the biomedical model, and then introduce the concept of resilience – centered on adaptation and flexibility – as a fundamental approach to managing public and universal health systems, especially within the field of collective health.

Since its conception, SUS has shared an affinity with the concept of resilience explored in this chapter. Its ongoing pursuit of increasingly resilient performance seeks to ensure full equity, integrality, and universality – safeguarding the quality and effectiveness of care, whether in acute crises or in the face of the chronic challenges that affect our health system. In this context, we highlight some key actions related to the reorientation of the SUS care model toward resilient performance, such as the adoption of Health Care Networks (HCNs), which take into account the vulnerabilities of territories and the social determinants of health in a comprehensive manner.

In the next chapter, we will broaden the discussion on resilience by focusing on the sharp end of the system, exploring aspects related to the work of multiprofessional teams in Primary Health Care (PHC).

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Chapter 4

Resilient Dynamics of Communities

The combination of professionals and territories with different characteristics is a factor of positive and negative variabilities.

In Brazil, Law 8.142/1990 establishes that the population must participate in all decision-making processes related to the implementation of health actions and programs. This participation takes place through an instrument known as social control. However, for social control to be truly effective, it requires the ongoing transformation of professional practices. This transformation must be grounded in critical reflection on the nature of health work and must closely connect the organization of care with professional training within the SUS.

This means that the training of health professionals must increasingly align with society's understanding of the nature of health services, so that effective responses can be provided and the SUS can remain resilient in the face of inevitable challenges and disruptions.

Thus, health education must go beyond technical training to also include the production of subjectivity related to care organization, welcoming the multiple dimensions and needs of people's health. However, changes in dominant practices within the health system and in professional training have been timid and fragmented, as have their impacts on policy formulation – which undermines SUS's potential for resilient performance.

This is a fundamental issue, as health work only takes shape in the interaction between professionals and users. The quality of this interaction directly influences both the effectiveness of care and the service's potential for resilience. Given this complexity, new technologies, processes and protocols emerge constantly, and keeping up with these changes demands a strong commitment to continuing education. The training of health personnel should be guided by real work processes, while also considering the variability introduced by social control – reconciling planned actions with the dynamic realities of the territory and the diverse professionals involved in care.

Overcoming the limitations of traditional professional training and practices is essential to achieving resilient performance, as health care rarely unfolds exactly as planned. This characteristic is not unique to health care but is inherent to any complex system. However, public health has particular dimensions of complexity that make variability even more evident, as we have previously discussed.

SUS's mission brings unique elements to this scenario. To ensure universal, equitable access and comprehensive care, it is necessary to go beyond the clinical approach, relying on knowledge of the social reality. This demands a practice that is multiprofessional, collaborative, intersectoral, and humanized.

In his renowned work The Principles of Scientific Management, Frederick W. Taylor advocates for prescribing work in the greatest possible detail, arguing that only through such precision could the predictability of the production system be increased (Taylor, 1911). Taylor's principles became widely known and highly influential in business schools. One of their most evident outcomes was the establishment of a culture of control as a central management tool.

In contrast, the Sociotechnical Systems Theory developed by Fred Emery advocates for reducing work prescription as a means to expand workers' scope of action, granting them greater autonomy to create necessary adaptations. From this perspective, it is not feasible to organize work and expect results based solely on predetermined, top-down rules (Emery, 1969). Work can be carried out differently from what was originally envisioned, anticipated, or prescribed – and still yield positive outcomes. Given the limitations of rationality, it is impossible to foresee every situation in advance. Therefore, fostering workers' engagement and autonomy enables them to adapt effectively to potential disruptions, particularly in highly complex situations.

In public health – and particularly in the case of the SUS – this theory proves highly relevant, as the multidimensionality and complex dynamics of Brazilian territories demand the implementation of its essential principles through multiprofessional care, which inevitably involves the coexistence of different perspectives on care.

> *A sociotechnical system is the synergistic combination of humans, machines, environments, work activities, organizational structures and processes that make up a given enterprise. This conceptualization mainly covers complex systems in which many humans collaborate towards a common goal, using technical support devices. A sociotechnical system must include individuals and teams; it needs coordination, control and management*

> *of limits of action. Its technical support is not limited only to equipment, machines, tools and technologies, but also to the organization of work (MUMFORD, 1999).*

Several studies on public health work highlight the persistent conflict between what is prescribed and what is actually performed (Anderson; Ross; Jaye, 2016; Arcuri *et al.*, 2022; Carvalho *et al.*, 2018). This discrepancy is a constant feature of healthcare, given the inherent instability of care practices. Health care cannot be reduced to strict compliance with protocols, as each prescription reflects only what was possible to anticipate within a work system. In contrast, the execution of activities depends on how individuals act within a dynamic and unpredictable scenario, shaped by multiple dimensions and components.

Thus, more recent theories challenge the principles proposed by Taylor in his famous work. One example is the Sociotechnical Systems Theory, which argues that it is not always possible to find a perfectly suited person for each task or to anticipate and control every outcome of the service. According to this perspective, it is unfeasible to fully predict or standardize workers' behaviors and needs without understanding their tacit objectives and individual motivations.

Sociotechnical systems operate within unique and dynamic scenarios shaped by the actions of people and emergent phenomena. Their functioning rarely aligns strictly with their original design, as it is continuously influenced by multiple and unpredictable factors. Given that resilience also depends on how individuals act to prevent and manage incidents, the central concern should not be the occurrence of the incident itself, nor solely whether someone made a mistake, but rather what people do routinely to avoid accidents and how they respond when they occur. In this sense, the focus of resilience should be on system dynamics in the face of sudden changes – not isolated events. Risks are inherent; some are known, others are not. To address this uncertainty, systems must be designed to foster the development of workers' resilience capacities and provide the necessary resources to ensure appropriate responses to unexpected events.

Most workers are engaged in their activities. Unless acting in bad faith, people tend to use the best approach available to them at the moment. This helps explain why performance goals are often met. In general, workers act with a certain degree of commitment and enthusiasm – whether because they find meaning in their work or to avoid negative consequences. When they diverge from prescribed procedures, it is often a reflection of their capacity to develop strategies to deal with unforeseen situations.

The frequency with which situations occur that require adjustments, leading workers to make adaptations, demonstrates the difference between Work-as-Imagined (WAI) and Work-as-Done (WAD). This terminology will always be present in any analysis of the potential of systems for resilient performance.

WAI and WAD are terms widely used in the Resilience Engineering literature to designate and describe misalignments between the way systems were designed to operate (how work was envisioned) and the way they actually operate (how work actually gets done).

Most health training programs are heavily based on WAI, with routines defined in detail through protocols, procedures, and performance goals.

In health service management, the gap between WAI and WAD has become the focus of numerous studies on resilience and safety, aiming to understand the adaptations that occur in everyday clinical practice.

In the traditional approach to safety, the gap between WAI and WAD is viewed as a risk. This perspective tends to disregard real working conditions, assuming that tasks can always be carried out exactly as prescribed, under ideal circumstances. Within this framework, any deviation from the prescribed process is seen as a human error or failure, and the goal becomes to minimize or eliminate the WAI-WAD gap. In contrast, the resilience approach recognizes that the stable functioning of complex systems depends on the ability to adapt to nonlinearities. From this standpoint, deviations – such as shortcuts and workarounds – are inevitable, as there will always be some degree of misalignment between protocols and the dynamic realities of everyday work.

As we have seen, both successes and failures originate from the system's adaptive capacity. For this reason, it is more productive to study what goes well in workers' adaptations than to focus solely on what goes wrong, as is commonly done through incident reporting, event mapping, and cause-and-effect analysis. Resilience thinking is rooted in the logic of complexity, where the gap between WAI and WAD creates the need for flexible practices and local variability to support overall system stability. At its core, resilience emphasizes the importance of learning from everyday successes. Constant efforts to minimize the WAI-WAD gap can help prevent failures, but they can also illuminate the adaptations that enable things to go right. These principles are especially relevant in public health, where it is inherently difficult to prescribe work rigidly in such an unstable, adaptive, and complex environment.

The concept of the health work process has its origins in medical services, but from the 1980s onward, it began to be used to describe the practices of other professionals in the health sector – especially as the expanded concept of health gained traction. Studies from the 1990s and early 2000s (Franco; Bueno; Merhy, 1999; Gonçalves, 1991; Malta; Merhy, 2003; Schraiber; Nemes, 1996) emphasize the importance of aligning health work and knowledge production with users' needs. Broadly speaking, work processes are seen as expressions of both these needs and the ways in which services are structured to meet them – thus offering a path for reorienting how care is organized.

Peduzzi (2001) defines multiprofessional work in health as a collective modality, built through the reciprocal, two-way relationship between multiple technical interventions and the interaction of professionals from different areas, configuring the articulation of actions and cooperation through communication.

The current concept of health work process – which incorporates a social approach, in addition to the technique – is essential in the practice of health management, permeating the configuration of care models, the conformation of teams, structural aspects and the entire dynamics of work actions. This concept is continuously affected by technological incorporation and other phenomena that affect the world of work, such as labor risks, crises of employability and precariousness, among others.

Given the multiprofessional nature of public health work, the concept of a health team is inherently linked to the principle of integrality

– even though, in practice, the idea that the various specialties involved in comprehensive care should be organized around medical work still prevails.

The division of tasks takes place within a broader social process of changing conceptions of health and disease, which in turn drives transformations in work processes. In a context committed to integrality, the effectiveness of care inevitably depends on well-articulated multiprofessional teams. Since resilience relies on the capacity to adapt, it is only natural that combining professionals with diverse training and practices introduces broader dimensions of variability – some of which can be absorbed, while others need to be managed or mitigated.

Therefore, health teams must be able to articulate a network of relationships among people and institutions with different knowledge, interests, and levels of power, all centered around a collaborative care process that also includes the user. The goals of teamwork should be defined in alignment with the scope of the health unit, the characteristics of the territory, and the available resources. In this model, a group of users or families is assisted by a basic reference team, supported by specialists working in a matrix-based structure. When organized in this way, the interdisciplinarity of the teams becomes a key element in overcoming the limitations of the traditional biomedical model.

For example, Primary Health Care (PHC) requires multiprofessional work as a prerequisite for organizing the health care process. Barbara Starfield (1932–2011) observed that, although teamwork was initially promoted to enhance physicians' performance, phenomena such as population aging and the emergence of new, persistent, or recurring diseases have created the need for broader and more qualified care.

This reinforces the movement in favor of multidisciplinary teams in PHC (Starfield, 1992).

The idea of multiprofessional care is reinforced by criticism of classical management models, which have influenced various production sectors. These models are often marked by excessive division and compartmentalization of work, as well as the fragmentation of tasks based on specialization.

Public health has specific characteristics due to its social and subjective nature. Health work always unfolds through the encounter between professionals and users – who, when seeking care, bring with them their personal histories and social and cultural contexts. In this complex interaction, users also take part in producing their own care. To respond to diverse health needs, the multiprofessional nature of the sector must be mobilized to ensure comprehensive care. The variability that emerges from these interactions should be understood as a factor that strengthens the resilience of health services.

According to Tulio Franco (2006), Professor at the Institute of Collective Health (ISC) of Fluminense Federal University (UFF), the micropolitics of the health work process is a dynamic and ongoing production that emerges from the social environments in which individuals are embedded. It is shaped by the relationships established among workers themselves and between workers and users. Since these processes are built daily through the actions of each worker, micropolitics becomes a space that reveals the service's resilient capacities to face unexpected events – regardless of their magnitude. This interconnection generates constant shifts and reinterpretations, which strengthen resilience through everyday practices. In a resilient system, the worker adjusts their work process freely in response to the specific context – because care is always unique, just as every encounter between a professional and a user is unique.

Franco also emphasizes that these "caregiving acts" – such as welcoming, listening, and building bonds – are conceived and carried out by all workers within a health service. These actions foster a differentiated perspective that helps deepen the understanding of each situation and engages both workers and users as active participants in the production of health. Attempting to deliver care in a purely prescriptive manner, without considering the reality at hand and restricting the adaptability of health workers, creates vulnerabilities. This approach distances services from actual demands and weakens their resilient performance.

The resilience of PHC in coordinating care

Barbara Starfield argued that, although PHC is the first level of care, it should play a central role in organizing and integrating Health Care Networks (HCNs), ensuring both coordination and continuity of care (Starfield, 2010). She was not the first to express this view. Back in 1978, the Alma-Ata Conference already emphasized the importance of PHC in the regionalization of health systems, recognizing it as the entry point and the first element in a continuous care process (World Health Organization, 1978).

> *Coordination of care is the ability to ensure continuity of care between different levels. It is classified into vertical (between PHC and the other levels of the system) and horizontal (between the PHC team itself, health services and social equipment) coordination (Almeida et al., 2018).*

Those who advocate that PHC should coordinate care argue that this approach enhances the system's ability to address the most prevalent health problems through the organization of HCNs, internal structuring, resource allocation, and clinical management. By reducing the pressure on higher levels of care, it strengthens the system's responsiveness. This, in turn, increases the potential for resilient performance, especially when faced with sudden surges in demand for more complex services.

In a system like the SUS, whose organizational model is centered on equity and comprehensiveness of care, PHC plays a key role in shaping care flows that group similar health needs. These care lines structure a flow of actions that include health promotion, prevention, treatment, and rehabilitation, targeting specific population segments, life cycles, gender, diseases, and events. This organization is a significant asset for promoting the system's resilient behavior. Notably, structuring SUS according to this logic requires consistent strategies for integrating different levels of care, navigating access across those levels, and – ideally – the use of technologies to support the management of these processes and flows.

Being responsible for organizing all the resources of the system to meet the demands of the population, PHC must strengthen its articulation with the HCN. This principle is strongly supported by PAHO, which states:

> *A health system based on PHC is formed by a set of essential structural and functional elements that guarantee coverage and universal access to services, which must be acceptable to the population and promote equity. Provides comprehensive, integrated and appropriate care over time, emphasizes prevention and health promotion,*

> *and ensures the user's first contact with the system, taking families and communities as bases for planning and action. (Pan American Health Organization, 2021)*

In turn, the HCN has its core in PHC, which organizes the flows, counterflows, and information regarding the population throughout the care process. As the main gateway to the system, PHC plays a key role in enhancing the health system's potential for resilience.

Although there is divergence, some studies support the idea that health systems centered on Primary Health Care (PHC) tend to achieve better outcomes in terms of equity and integrality (Almeida *et al.*, 2018; Arcuri *et al.*, 2020; Bousquat *et al.*, 2017; Forrest, 2003; Sripa *et al.*, 2019). In theory, these systems have a greater capacity to mobilize resources, are less costly and more efficient, provide faster access, and help reduce hospitalizations. All these factors enhance the system's ability to anticipate extraordinary demands, monitor health conditions, generate knowledge from practice, and respond more effectively – key competencies for resilient performance.

In addition to Brazil, countries such as China, India, and South Africa have also made political commitments to universal health coverage, placing primary care at the core of their health systems. These nations share common challenges – but also opportunities – to enhance population health through more integrated, accessible, and people-centered healthcare systems.

The COVID-19 pandemic highlighted the importance of a health system in which Primary Health Care (PHC) plays a central role in coordinating care. This includes promoting multisectoral policies and actions, as well as integrating health services within local territories. A PHC-centered, integrated, and multisectoral approach enables more direct action on the social determinants of health, strengthens the capacity to monitor and anticipate risks at the local level, and improves planning, programming, and decision-making across all sectors involved in service delivery. It also supports the strategic prioritization of key health services in line with local contexts.

Primary Health Care (PHC) is typically the first point of contact for communities during emergencies. Therefore, it is essential that services at this level are adequately trained to respond effectively to extraordinary events and are equipped with the necessary resources to ensure the continuity of essential services, both for individuals and the broader community.

Summary

In this chapter, we highlight that the role of Primary Health Care (PHC) in organizing care, as recommended by SUS, calls for a renewed perspective on the work of multiprofessional health teams. Operating in often vulnerable territories and under precarious conditions, these teams face variabilities that demand constant adaptations. In this context, resilience emerges as a fundamental attribute for ensuring effective health action.

Prevention based on Primary Health Care (PHC) – as the gateway to the health system – strengthens resilience by enabling the early identification of problems, preventing their worsening, and, in extreme situations, avoiding the collapse of the care network at other levels of care.

Finally, the COVID-19 pandemic reinforced the role of Primary Health Care (PHC) at various stages of the public health disaster management cycle, while also strengthening key resilience capacities such as anticipation, preparedness, response, monitoring, and learning.

In the next chapter, we will describe, based on theories of complex sociotechnical systems, the guiding principles that underscore the importance of an approach that recognizes and incorporates this complexity.

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Chapter 5

Universality and Equity Through a Complexity Lens

The SUS should focus on the interactions between its components and with the external environment, highlighting the actions that keep its structure in good working order.

In Chapter 3, we saw that, since its inception, the SUS has developed adaptation mechanisms to face the complexity and challenges of implementing a universal, comprehensive, and equitable health system in Brazil. These essential principles were reinforced by the Brazilian Health Reform Movement of the 1970s and 1980s, during the military regime, which culminated in the creation of a legal, normative, and operational framework. However, putting this framework into practice as envisioned has proven difficult, given the turbulent economic, social, and political context.

As we have seen, the SUS was conceived to be more than just a a compilation of services. In fact, Sérgio Arouca – one of its main architects and thinkers – emphasized that the SUS "is not, in any way, a simple health insurance plan". It goes far beyond that: the SUS is an active and strategic component of the Brazilian productive system.

Everyone should have access to a comprehensive range of quality health services that meet their needs – from health promotion and prevention to treatment, rehabilitation, and palliative care – whenever and wherever they need them, without barriers. To fulfill this commitment, countries must ensure strong, efficient, and equitable public health systems that are responsive to population needs and capable of addressing the environmental and socioeconomic factors that influence health and well-being. This includes being prepared for, responding to, and recovering from health emergencies.

Addressing the social determinants of health helps us understand the epidemiological context, identify the social and health needs of a given territory, improve and expand access to services, and reduce poverty and inequalities. However, even when services are available and accessible, people may still not use them for various reasons – such as lack of awareness, mistrust, or other barriers.

Therefore, the great challenge for the 21st-century health systems is to ensure both broad and continuous access to quality health services and effective social protection. The concept of coverage is inherently linked to access – the two are complementary. Without universal access, achieving universal health coverage remains an unattainable goal.

When analyzing the historical context of the creation of the most recent public health systems, the organization and genesis of the English health system stand out as a key milestone. Recognized as one of the oldest public health systems in the world, it served as a model and inspiration for the development of many others (Cash, 2019).

During the Industrial Revolution in England, the workforce – which included nearly the entire population, from children to the elderly – was subjected to long working hours and unhealthy conditions, both in the workplace and at home. These factors, combined with poor urban infrastructure and a lack of basic sanitation, severely worsened the health of workers. As a result, persistent patterns of illness and death emerged, marked by a high incidence of infectious and parasitic diseases, elevated general, infant and maternal mortality rates, and low life expectancy. Globally, life expectancy at birth has risen from 47 years in the mid-20th century to around 70 years today, with projections reaching 76 years by the mid-21st century (Leeson, 2014).

This situation led to an official investigation, whose findings were compiled by Edwin Chadwick in his 1842 report, which became widely known by his name. This movement, known as "Sanitarism" or the Public Health Movement, emphasized legally enforced environmental sanitation measures. One of its key outcomes was the enactment of the Public Health Act of 1848.

In the second half of the eighteenth century, urbanization became a priority, especially in large cities, with the goal of organizing urban space in a cohesive and standardized way, under a single, well-regulated authority – initially driven by economic interests. Efforts to improve the population's quality of life were closely tied to these objectives, with the main motivation being the economic value of maintaining a healthy and productive workforce.

In addition to economic factors, political reasons also played a role. Various groups – such as guilds, trades, and corporations – entered into conflict, gradually polarizing into a broader struggle between the rich and the poor, between commoners and the bourgeoisie. This tension, which grew throughout the eighteenth century, was expressed through increasingly frequent episodes of urban unrest, culminating in major historical events like the French Revolution. As the working class emerged and underwent a process of proletarianization, urban conflict became more common.

Therefore, it became necessary to establish a political authority capable of governing the growing urban population. The bourgeoisie adopted a model of intervention already in place: urban medicine. This approach was based on surveillance and hospitalization practices and represented an evolution of the political-medical quarantine strategies used since the late Middle Ages. Public hygiene, derived from these quarantine measures, became the driving force behind the development of urban medicine in the second half of the eighteenth century.

On the other hand, in 1920, the Dawson Report was published in England. It incorporated criticism of the Flexnerian model and proposed a rationalization of technologies and the social provision of healthcare, based on specific social demands. The report suggested reorganizing the care model through services structured by levels of complexity and treatment costs, introducing for the first time a network-based scheme for organizing healthcare – although this model was only implemented in 1948. Foucault (1979), in his analysis of Modernity, identified the emergence of social medicine during this period, defining it as a strategy of biopower, that is, a form of social control over individuals through the regulation of human bodies. One of the main concerns of urban medicine, according to Foucault, was the organization and control of water and sewage systems, since urban disorder and the lack of basic sanitation were considered – since the second half of the fourteenth century – major causes of epidemic diseases in cities, particularly in London.

Although elements such as disease prevention, the maintenance of well-being, and health promotion can be traced back to ancient societies, it was the Industrial Revolution that marked the turning point in defining a widely accepted concept of public health. This culminated in the seminal 1920 publication by Charles-Edward Winslow.

In his definition, Winslow emphasizes the integral, collaborative, and interdisciplinary nature of providing services aimed at maintaining people's health and well-being. This perspective remains highly relevant, as it underscores the inherent complexity involved in developing public systems capable of broadly serving entire populations.

Schematically, systems can be understood as sets defined by three key elements: purpose, structure, and function. The purpose is expressed through the organization of components to achieve a specific goal. This organization gives rise to a structure, articulated through the interaction of functions. Such configurations allow the system to be assimilated by a broader sociopolitical framework – or, on a smaller scale, by a device, machine, or set of rules – designed to produce a specific outcome.

One of the leading scholars on the topic of complexity in sociotechnical relations, Edgar Morin developed a theory to better understand multidimensionality, the dynamics of interactions, and the cognition of people who navigate highly variable situations. His Complexity Theory argues that humanity operates under a dominant paradigm of simplification, reductionism, and abstraction – one that fosters technocratic distortions. According to Morin (2007), this paradigm must be transcended in order to effectively engage with the complex realities of everyday life.

Morin stresses key aspects of resilience, particularly the idea that the root cause of error often lies not in the failure itself, but in the routine ways workers within an organization structure their knowledge. He defines complexity as a "fabric of inseparably associated heterogeneous constituents". These constituents may include events, actions, interactions, feedback loops, determinations, and accidents – all intertwined, yet marked by disorder, ambiguity, and uncertainty regarding the phenomena that people constantly strive to organize, structure, and classify.

Von Bertalanffy's (1972) General Systems Theory examines the abstract organization of phenomena, regardless of their specific formation or current configuration. It explores the principles that are common to all complex entities and the models that can be used to describe them. According to Von Bertalanffy, a system is an organized whole composed of a set of elements and their interactions. Thus, there are models, laws, and principles that can be applied universally to systems, regardless of their type, the nature of their components, or the relationships among them. In his theory, systems are categorized into two types:

- Open systems: These systems engage in continuous interactions with their environment, generating both positive and negative feedback. Their functionality depends on these interactions, making them self-regulating. Through self-regulation mechanisms, open systems maintain an internal organization that ensures their stability over time, even in the face of increasing complexity. The SUS (Brazilian Unified Health System) is a typical example of an open system;
- Closed systems: These systems operate in isolation from their environment, functioning independently of external interactions. A clock is a classic example of this type of system.

According to Von Bertalanffy, open systems are subject to both positive and negative self-regulation through a circular process in which part of the system's output is fed back as input. Negative feedback amplifies fluctuations in the system's functioning and drives changes that may impact its stability, while positive feedback counteracts variations, helping to stabilize performance. These regulatory mechanisms are tools used by agents to manage variability.

Mario Cesar Rodriguez Vidal, a professor at the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering (COPPE) at the Federal University of Rio de Janeiro (UFRJ) and a pioneer of Brazilian Ergonomics, argues that no work activity takes place in isolation; it always unfolds within a sociotechnical system. Consequently, the system's functioning depends fundamentally on its sociotechnical characteristics (Vidal; Carvalho, 2008).

In Sociotechnical Systems Theory, workers do not merely adapt to the system – they also actively modify, reshape, or redesign it. Consistent with Von Bertalanffy's concept of an open system, the interactions between a sociotechnical system and its external environment are intrinsic to its functioning. Traditionally, systems have been analyzed by dividing them into distinct parts, allowing for a component-by-component examination to understand the behavior of the whole. This method decomposes systems into separate physical elements and isolates their behavior into discrete events. Rooted in classical engineering, this approach assumes that such separation is both conceptually and methodologically feasible – that each component functions independently and that analyzing parts in isolation will not distort the understanding of the system's overall behavior when the components are recombined.

However, this assumption does not hold true for complex sociotechnical systems, in which interactions between components and events are often indirect, dynamic, and characterized by emergent properties. In such systems, the overall output cannot be accurately predicted based on the isolated functioning of individual components. Instead, it arises from the interplay of interdependent elements, whose behavior may change over time and under varying conditions.

Characterizing public and universal health systems such as the SUS from the perspective of complexity allows us to think about the system holistically, focusing not only on its structures but mainly on the interactions between its components and the external environment. This perspective makes it possible to highlight the implications of these systems' potential for resilient performance, which depends on understanding such interactions and developing competence daily through actions that sustain proper functioning.

In the systematization of care, the historically and intrinsically unstable context of service provision leads to adaptations at different levels. Resources are always limited, and demands follow their own dynamics, making it necessary – and beneficial – for health systems to be prepared to operate in a context of constant change. Governments, service providers, and even citizens will seek ways to adapt to evolving conditions to safeguard health and well-being. Naturally, the outcomes of this collaborative health production process will also vary. These variabilities can, of course, lead to both positive and negative outcomes.

That is why strengthening the intrinsic adaptive capacity of health systems involves enhancing their ability to respond to both everyday and extraordinary demands. Often, this adaptive ability is attributed to the behavior of health system users – a form of informal resilience – operating beyond the control and awareness of the system's governance structures. To make resilience a component of health management, it is essential to properly identify how this adaptive capacity influences the variability of outcomes in essential public health functions.

When faced with fluctuations in demand – including public health events of national or international significance – health systems must have sufficient capacity to manage such events while maintaining responsiveness in their routine operations, as the regular needs of the population do not cease during extraordinary circumstances.

The epidemiological situation in resource-limited settings, such as middle- and low-income countries, diverges significantly from the classic Omranian epidemiological transition observed in developed nations. It is characterized by a triple burden of disease, which includes: (1) an unfinished agenda of communicable diseases, malnutrition, and reproductive health issues; (2) chronic non-communicable diseases and their associated risk factors (such as smoking, overweight, obesity, sedentary lifestyle, stress, and diets high in ultra-processed foods and fast food); and (3) a marked rise in external causes (such as accidents), which have become leading contributors to morbidity and mortality (Omram, 2001).

Resilient systems must mitigate the mismatch between a fragmented, episodic, and reactive health system – primarily focused on acute care and the exacerbation of chronic conditions – and the complex epidemiological scenario described above.

Health care models are structured technological arrangements designed to solve problems and address the health needs of the population – whether individual or collective – by mediating between technical and political dimensions. In some countries, however, health promotion and prevention are often neglected in favor of emergency-driven actions. These are typically characterized by a campaign-based approach, focused primarily on controlling endemics and outbreaks and providing individual care, following a hospital-centered, fragmented, and physician-dominated model rooted in Flexnerian principles. Resilient health systems, by contrast, must prioritize the continuity of public health actions – not only during crises, but as a consistent and integral part of care delivery.

Some services or programs – though designed, developed, and implemented as stand-alone units – can be sufficiently complex and adaptive to function as subsystems within a larger system, even if they cannot operate entirely in isolation. This organization, in which a complex system is integrated with other equally complex systems, is the focus of a set of theories grouped under the concept of System of Systems (SoS), which we briefly introduced in earlier chapters.

An SoS is, at its core, a collection of systems that integrate their resources and capabilities to form a new, more complex system – one that delivers greater functionality and performance than the sum of its individual parts (Ackoff, 1971). Although the term SoS is relatively recent and still evolving in its formal definition, it is commonly used to describe configurations in which the individual components are themselves complex, fully functional systems. When brought together, these systems increase the overall complexity and capability of the encompassing system.

To illustrate this characterization within the scope of the SUS, consider the example of the Health Economic-Industrial Complex (HEIC). By promoting a more explicit connection between the health sector and the broader Brazilian industrial complex, the HEIC strengthens the resilient performance of the SUS. It demonstrates how other economic sectors contribute to the production of essential inputs for health service delivery – such as medicines and vaccines – critical for adapting to unexpected events and crisis situations.

According to Carlos Gadelha, the Health Economic-Industrial Complex (HEIC) combines various activities and economic sectors within the productive and service dimensions characteristic of the health field. By systematically integrating the principles of collective health and structuralist thinking to address long-standing weaknesses in Brazil's development model, it positions the health sector as an integral component of the country's economic and social structure. For Gadelha, health is an endogenous element of development – not an external factor – going beyond the notions of human capital or political structure.

It is a gigantic yet inescapable challenge: a model of articulation between industry and health services through management technologies, regulated by a State that ensures universality, equity of access, and comprehensive care. This model supports the reorganization of the development framework in a peripheral and unequal country. Although we will not explore this conception in depth, it serves to illustrate yet another element of the complexity in which the SUS is embedded – and which it also helps to shape – since health in Brazil is part of the productive sector, going beyond its care function to actively contribute to a broader national development project.

Another aspect closely tied to complexity and resilient performance is the effective participation of workers in the design and management of such systems. The French physician Alain Wisner (1923–2004), considered the founding father of modern ergonomics, published extensive work on this subject. According to Wisner, involving workers in the design and implementation of systems yields numerous benefits, such as increased satisfaction, greater acceptance of change, and improved integration of technology into work processes (Wisner, 1995). Workers thus play a central role in the conceptualization and implementation of sociotechnical systems, in promoting safety, and ultimately in fostering resilience. Wisner referred to this approach as Participatory Ergonomics.

From a sociotechnical perspective, a health system is a formal organization of contractually integrated care providers operating under common governance arrangements that foster multiprofessional and technological coordination across various levels of care, in line with users' needs. These systems may include horizontally integrated organizations (e.g., hospital networks) or vertically integrated structures (e.g., linking primary, secondary, and tertiary care). At their core, such systems should be governed participatively, with the involvement of managers, health workers, and users, supported by appropriate logistical and financial resources. This structure requires consistent collaboration among workers throughout the system, guided by best practices and grounded in the best available scientific evidence.

From the perspective of Von Bertalanffy's theory, health systems are considered open systems because they are influenced by external factors such as poverty, education, local infrastructure, and, more broadly, the social and political environment. This includes both efforts to influence health determinants and more direct actions aimed at improving health. A health system, therefore, is much more than a pyramid of public facilities providing personal health services – it encompasses all institutions, people, and resources involved in the continuum from policy formulation to care delivery.

The pursuit of universal health coverage is primarily rooted in the value of equity. When immediate universality is not feasible, progress must be made in a fair and equitable manner – this should be the primary concern at the blunt end of the system. A well-functioning health system relies on trained and motivated health workers, a well-maintained infrastructure, and a reliable supply of medicines and technologies, all supported by adequate funding and evidence-based policies.

Resilient behavior entails the ability to rapidly mobilize core components of the health system, including the provision and continuity of care, as well as the availability of human, financial, and technological resources – not only during emergencies, but also to support the ongoing strengthening of the system itself. The organization, management, and delivery of services constitute the most visible indicators for assessing system efficiency, particularly in times of crisis.

In the SUS, collaboration with other stakeholders is also essential – particularly with private sector entities – given the current structural limitations of the Brazilian public sector. Local healthcare providers, communities, and civil society can also play a critical role in service delivery. Medical products, vaccines, and technologies are key components of system responsiveness and, as such, are fundamental elements for resilience.

Another critical factor for effective response and preparedness in the face of disruptions is the health workforce – its size, availability, experience, and training. For example, in user reception, professional skills are a key determinant of success. Health systems are therefore particularly reliant on the competence of their professionals, as well as on the coordination and alignment of protocols developed across professional categories.

Often, the blunt end of the system – by failing to capture what occurs at the sharp end – is unable to respond adequately to demands. Although care coordination itself takes place at the sharp end, it must be aligned with management levels at the blunt end to ensure that the necessary resources and conditions are in place for a harmonious relationship between users and professionals. Even conflict can serve as a source of collaboration, as it is natural for professionals with diverse practices and beliefs to experience goal-related tensions – without this necessarily compromising the quality of care.

Coordination can take place in three main forms: vertical, lateral, or longitudinal. Vertical coordination refers to the distribution of tasks across different levels, based on criteria such as experience or hierarchy. In lateral coordination, tasks are shared among workers operating at the same level. Longitudinal coordination occurs when tasks are delegated both laterally and vertically, with the activity flowing across different levels and involving various workers at each level.

In health work, it is common to distribute tasks based on each worker's experience. For instance, more experienced physicians often supervise residents and are available to intervene when needed, establishing vertical coordination at the sharp end. At the blunt end, the organization tends to self-regulate in response to emerging situations, reallocating available resources laterally among individuals from different areas. Finally, user care is often managed longitudinally by multiple professionals from various teams, in a continuous and collaborative manner.

However, these modes of coordination should be employed with caution. A hospital-based study by Belgian ergonomist Anne-Sophie Nyssen documented cases in which poor coordination of care created information gaps that hindered the ability to trace patients' trajectories through the health system (Nyssen, 2017). In several instances, patients sought care repeatedly through different entry points after being dissatisfied with previous encounters. Each time, care was restarted without acknowledging prior consultations. In some cases, this lack of continuity contributed to patient deaths.

Some sociotechnical systems are more complex than others, but certain features of contemporary organizations – such as the interdependence among their components – mean that all systems must contend, to varying degrees, with some level of complexity. As a result, the need for analytical frameworks and management approaches that align with the nature of complexity has become increasingly evident. In the field of Ergonomics and Human Factors, the complexity perspective has gained prominence, as it deepens the understanding of how sociotechnical systems function and enhances the analysis of accidents and the design and use of support tools, among other applications.

Despite its broad scope, the term *complexity* is often misused – confused with mere difficulty of action. As a result, the methods applied by ergonomists are not always compatible with the actual complexity of the systems they are analyzing. Since the design principles for sociotechnical systems operating at higher levels of complexity are quite specific, it is essential to understand under which circumstances these principles truly reflect system performance.

In general, the characteristics of complexity and corresponding management guidelines are not derived from primary empirical data or direct observation of work, but rather from secondary sources or hypothetical scenarios. The relationships between these guidelines and actual system functioning are also insufficiently explored. This is particularly ironic, given that analyzing relationships is essential to understanding system complexity. Without this, analyses risk falling into a reductionist view – merely highlighting how difficult it is to manage system attributes, as Edgar Morin cautions.

An interesting perspective on complexity is offered by Critical Realism (Archer *et al.*, 2013). According to this view, reality exists independently of our perceptions, which means that all observation is inherently limited. Complexity is real and, in theory, can be measured – but biases constrain the objectivity of its description. Since all systems contend with some degree of complexity, it is not accurate to state, in binary terms, that a system is or is not complex. Likewise, it is not appropriate to claim that a system is or is not resilient. Systems are more or less complex – or, more precisely, they experience moments of greater or lesser complexity – just as they may display varying levels of resilience potential.

French ergonomists Bernard Pavard and Julie Dugdale define complex systems as those in which it is difficult – or even impossible – to reduce the number of parameters or characteristic variables without compromising their essential functional properties (Pavard; Dugdale, 2006). They align with thinkers like Morin and the Critical Realism perspective in asserting that a complex system is inherently irreducible. When a system cannot be abstracted into a simplified model that considers only selected aspects at the blunt end, designing support tools for operators at the sharp end becomes significantly more challenging. According to these authors, complex sociotechnical systems exhibit four specific properties:

- **Indeterminism:** It is impossible to accurately anticipate the behavior of systems, even when their functionalities are fully known;
- **Limited functional decomposition:** It is difficult, if not impossible, to study the properties of the complete system by its decomposition into stable parts;
- **Information and representation of a distributed nature:** Some of its functions cannot be situated in a single place. The information is naturally located in several spaces and, in some cases, in the possession of several actors. A system is distributed when its resources are physically or virtually spread across multiple locations. This distribution may occur due to separation of duties, redundancy, diversity, contingency or as a result of work organization;
- **Self-regulation (or self-organization) and outcrops:** If situations are unpredictable, new information emerges in an unpredictable way. In order to make the flow of information understandable, the actors of the system reorganize their structure, even changing their cooperation mechanisms, both in the sharp-end and in the blunt-end. The transmission of information between agents depends on environmental factors and informal cognitive control exercised individually. An outcropping does not occur due to incomplete information

> about the components of the system, but to the non-linear and distributed aspect of the interactions. It is important to emphasize that in a system capable of reorganizing itself, functions with a response time longer than the demands compromise stable functioning.

According to Pavard and Dugdale (2006), it is possible to identify relevant and central aspects of how complex sociotechnical systems function. However, two key factors must be taken into account: the possibility of unexpected events occurring and the inherent limitations workers face in fully describing their own work.

Variability – or the use of improvisation by workers in carrying out their tasks – is also inherent to these systems, as it serves to bridge gaps caused by under-specification of work, allowing the system to achieve its intended outcomes.

As complexity increases, so does the likelihood of new types of failures emerging, since a greater number of process variations can combine in unexpected ways. In critical complex sociotechnical systems – such as health systems, where users' physical integrity is at stake – the design of support tools must increasingly incorporate elements that reflect how work is actually carried out. The goal should always be to reconcile WAI with WAD, rather than using WAI to override or suppress WAD.

Regulatory actions aim to reconcile WAI and WAD in order to keep the system operational and stable over a given time interval. This enables the system to fulfill its purposes, even when faced with endogenous or exogenous disturbances. Such self-regulation follows a spiral dynamic, where part of the system's output is fed back as input to the system itself. It relies on interventions that either amplify or dampen the output of a given function. Positive self-regulation (feedforward) amplifies outputs to accelerate responses but may compromise system stability. Negative self-regulation (feedback) attenuates output variations to stabilize system functioning. This regulatory process takes place within the space of workers' adaptation to the unexpected. Therefore, the more room systems allow for informed adaptation – supported by adequate resources – the greater their potential for resilient performance.

Regardless of whether its application is autonomous, a technological system is always embedded within a sociotechnical context. All systems are conceived, built, and operated by people. They are designed to produce something with a specific purpose, directed toward a user. This intentionality is what allows the system to be represented and supported by a device, a machine, or a set of rules.

Recognizing the distributed nature of systems reveals how their ability to manage unpredictability depends on information control across all layers. The formation of Health Care Networks (HCNs) within the SUS exemplifies this multilayered structure of complex sociotechnical systems, marked by numerous intersections – each with distinct characteristics involving professionals and users operating in diverse contexts and situations.

HCNs are organized in ascending levels of complexity, allowing users to navigate through different tiers via coherent care flows, while health workers access the technical layer at various points to obtain the knowledge and technologies needed for appropriate care. Since this flow is never linear, coordination must account for the actual needs and movements of both workers and users, who enter the system through multiple entry points and at different times. These user trajectories must be understood from both the sharp-end and the blunt-end of the system.

Decision-making in health care takes on multiple forms throughout the care process – for example, physicians often rely on specific sets of protocols. However, in practice, rules, decision models, and even clinical information are far more complex than they may initially appear. In this context, the mental models used by health professionals in carrying out their technical functions become particularly important, given the wide variety of tasks performed collectively.

Health work is a very particular form of technical activity, as the actions of professionals have consequences not only for themselves and for users – on an individual level – but also for the organization as a whole.

Summary

In this chapter, we have shown how theories on complex sociotechnical systems influence the resilience of health systems. We also explored how such systems align with the principles that underpin the SUS, and how concepts from complex adaptive systems can support the analysis, design, and management of health systems to enhance their resilience.

In a country of continental dimensions, marked by political, territorial, and vulnerability-related challenges, as well as chronic inequalities, achieving the principles of universality, integrality, and equity demands a dynamic organization of systems, subsystems, services, and programs that must be effectively integrated and managed.

The SUS can be understood as a System of Systems (SoS), in which units, actions, and programs are sufficiently complex and adaptive to function as subsystems within a larger whole, yet cannot operate in isolation. From this complexity perspective – where variability is the norm rather than the exception – resilient functioning becomes essential.

When Edgar Morin critiques the hyperspecialization and fragmentation brought about by rapid technological advances in the complex fabric of realities, knowledge, and practices, he offers valuable insights for understanding the organization and functioning of Health Care Networks (HCNs). Similarly, the properties described by Bernard Pavard and Julie Dugdale are clearly reflected in healthcare models. Care is self-organized in response to emerging events shaped by territorial contexts, in a non-deterministic manner. Coordination – whether lateral, vertical, or longitudinal – distributes information flows, particularly under the premise of multiprofessional care.

Finally, we have seen that care cannot be fully decomposed without compromising its essential properties, as the reassembly of its components may not recreate the whole – highlighting that the sum of the parts does not necessarily equal the system as a whole.

In the next chapter, we will explore the intrinsic potential of the SUS to develop resilience capacities as a new approach to safety in care, taking into account not only how it was originally designed, but above all how it is implemented and operated in practice.

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Chapter 6

Resilience: A Novel Paradigm on Public Health

The first challenge for resilience is recognizing that complex systems are dynamic and may become unstable at any moment.

Although widely used in psychology, the concept of resilience remains underutilized in the design and management of health systems – particularly within the field of public and collective health. In the foreword to his book Resilient Health Care, Erik Hollnagel notes that "probably only a few [scholars] know for sure what [resilient health care] means" (Hollnagel; Braithwaite and Wears, 2015, p. 29). Research on resilience in health systems has largely focused on responses to crises and disasters, such as epidemics and natural catastrophes.

Initially, most applications of the term *resilience* in health systems centered on major disruptive events and how systems could absorb, adapt, and transform to cope with such crises. This perspective was grounded in research focused on preparedness and immediate response to so-called natural disasters and was strongly influenced by recommendations from international bodies such as the United Nations Office for Disaster Risk Reduction (UNDRR).

With the occurrence of multiple crises that have directly or indirectly affected population health over extended periods – such as wars, climate events, population aging, migrations, and epidemics – the scope of research on systems resilience has expanded to include risk reduction and the management of prolonged stress. As a result, resilience has come to be understood as an everyday capability, essential not only for acute responses but also for coping with ongoing and chronic stressors.

This broader approach was first introduced by international bodies in 2014, when the European Observatory on Health Systems and Policies and the Organization for Economic Co-operation and Development (OECD) published a report assessing the institutional capacity of European health systems to respond to events with disruptive potential (Thomas *et al.*, 2020). The initiative was highly significant, as it positioned the concept of resilience – and the capacity of health systems – at the core of investments and reforms aimed at achieving universal access, coverage, and both individual and collective health security.

It has become essential to develop ways to assess the potential of health systems for resilient performance, now increasingly recognized as a key attribute. While resilient performance necessarily involves responding to events, such events are not a prerequisite for evaluating a system's resilience potential. Resilience is, above all, an everyday capability – and a resilient health system must be prepared for disruptions that may never occur. Ideally, such disruptions would not happen at all, though in public health, this remains a utopian scenario.

Some aspects of SUS services appear to offer opportunities for establishing protocols and prescriptions that typically serve as important control mechanisms, particularly in care practices. Although widely adopted, such controls often overlook the inherent variability of health work – an aspect that becomes particularly relevant when assessing whether a system tends toward resilience or fragility.

Take for example the Brazilian Primary Care Policy (PNAB)[1]. Far more prescriptive than other policies that typically outline only general guidelines, the PNAB includes chapters that define, in detail, the responsibilities of professionals within Primary Health Care (PHC) teams – covering both common and specific tasks. This inventory of attributions is used to establish targets for individual and collective activities and plays a central role in determining the transfer of resources for program implementation at the municipal PHC level.

From a resilience perspective, it is important to recognize that the inherent variability of health work contexts will inevitably lead to adaptations in activities. For instance, patient registration – linked to the goal of maintaining up-to-date records of enrolled populations – will vary depending on the dynamics of each territory.

In a system designed with a focus on resilient performance, variabilities of this nature should be taken into account when setting and evaluating management goals, rather than being treated merely as deviations from policy implementation. The PNAB itself, in its general provisions, affirms this perspective by stating its commitment to "the person in their uniqueness and socio-cultural context", to "overcoming simplistic understandings", and to recognizing "that health has multiple determinants and conditions, and that improving the health of individuals and communities involves multiple factors".

Especially during extreme crises, strict controls are rarely applicable in full, as situations evolve rapidly under increasingly uncertain conditions that fall outside the scope of initially designed mechanisms.

(1): https://bvsms.saude.gov.br/bvs/saudelegis/gm/2017/prt2436_22_09_2017.html

The interplay between regulation and care poses ongoing challenges to the adaptive capacity of SUS services, particularly given that health organizations often operate in a state of continuous crisis management. To foster resilience, control should not function as an authoritarian or dominant force – even when expressed through prescriptions, protocols, or performance targets. In organizations composed of multiple actors with divergent agendas, rationalizing decision-making should not aim to eliminate variability, but rather to analyze it and, from that understanding, either dampen or incorporate it into the system's routine operations and, ultimately, into health management models.

Several studies highlight the advantages of incorporating resilience into strategies for managing work in complex, under-specified, and uncertain environments – such as aviation, the military, nuclear energy, and, notably, public health. According to leading literature, the primary connection among these complex domains is safety (Braithwaite; Wears; Hollnagel, 2016; Hollnagel; Woods; Leveson, 2007; Nemeth; Wears; Woods, 2008).

Resilience views safety not merely as a retrospective exercise in failure analysis, but as a proactive capacity – centered on how workers anticipate potential adverse outcomes and act to prevent them. Therefore, the analysis and understanding of variability must be integrated into the control mechanisms adopted at both the blunt end and the sharp end of the system.

Erik Hollnagel was among the first to argue that organizational systems can be designed across different levels to create and sustain fault-tolerant strategies, anticipate potential pathways to failure, and adjust tasks and activities to preserve safety margins under pressure. According to him, resilient systems are capable of adapting and reorganizing effectively to respond to varied – even atypical – demands.

The systematic application of techniques to achieve this is the central focus of Resilience Engineering.

Traditional risk assessment, which is conducted retrospectively based on past disasters, is more effective in well-defined, relatively stable domains where major events can be anticipated – such as the loss of cooling in a nuclear reactor or the failure of an aircraft's engines. However, even in these fields, this approach alone is insufficient to prevent serious accidents.

In contrast to traditional risk assessment, Resilience Engineering adopts a prospective approach – focusing on how the system functions and anticipating ways to respond to future events, even those not previously identified. Consider a typical scenario in the SUS: managing conflicts between the demand for emergency care and political pressures for resource restriction. Rather than applying temporary fixes, Resilience Engineering seeks to understand the system's adaptive capacity and incorporate variability into service design. A design that allows for adaptation can help minimize disruptions in continuity of care and reduce system strain, ultimately enhancing safety.

Outpatient care offers an emblematic example of complexity, both at the blunt end and the sharp end. At this level of multiprofessional care, various elements – such as facilities, equipment, procedures, patients, and their families – are intricately connected in a highly collaborative process. Professionals face constant pressure to reconcile conflicting agendas while maintaining a standard of care aligned with professional guidelines, all in response to the needs of a diverse patient population.

Challenges in this scenario include strained relationships between users and healthcare professionals, as well as uncertainty regarding the availability, accuracy, and timeliness of patient information.

These issues mirror those faced by crisis response agencies when weak or ambiguous inter-organizational relationships hinder timely decision-making during emergencies. Similar dynamics occur in urgent care settings, which are marked by high variability, contingency, and uncertainty – where both the type and volume of demand are unpredictable, and users may arrive at any time. To align care resources with fluctuating demand, teams must engage in dynamic activities supported by flexible and adaptable tools.

Under no circumstances is it acceptable to suspend service. Aware of this, health teams develop a range of sophisticated strategies to manage the balance between resources and demand, using techniques to prevent or cope with unstable conditions involving sudden or critical shifts. Rather than attempting to control every possible scenario, formal spaces should be established to intentionally support workers' adaptive actions in maintaining overall system stability. Despite such adaptations, uncertainty and gaps in continuity of care remain common features of health work. Understanding these gaps is essential for designing systems and services that are more aligned with real-world practice.

Organizational safety through resilience

Safety management strategies are predominantly retrospective, centered on the analysis of past adverse events – particularly failures attributed to human error. This is a natural trend, rooted in the human impulse to prevent harmful events from recurring. It reflects a fundamental aspect of human nature: the inclination to understand the past in order to better navigate the future. In trying to make sense of what occurred, our attention is inevitably drawn to what went wrong in that specific episode.

Safety and risk prediction approaches develop incrementally, that is, those tried and trusted are only changed when they fail. As for variability, it is generally considered an undesirable element.

Despite significant progress in understanding how accidents occur, there has not been a corresponding advancement in how to assess and reduce risks. Since accidents and hazards are addressed by related models and theories, one might expect safety developments to have evolved in parallel. However, the investigation and reporting of most accidents face practical challenges – such as defining the scope of the event, identifying the necessary data, documenting findings, and formulating effective recommendations.

From the perspective of traditional safety – what Hollnagel refers to as Safety-I – disturbances are viewed as the result of a sequence of factors, with the accident representing the final link in the chain. In this view, accidents are invariably caused or triggered by an unsafe act, seen as an extraordinary disturbance imposed on an otherwise stable system.

Resilience Engineering is grounded in a different safety management paradigm – referred to by Hollnagel as Safety-II (Hollnagel, 2014) – which emphasizes supporting people in managing complexity under pressure to achieve successful outcomes. This approach contrasts sharply with the traditional notion of treating error as a discrete object of analysis. In a resilient organization, safety is a core value expressed through day-to-day operations – for example, by investing in the anticipation of events that have not yet occurred, based on the understanding that knowledge gaps are inevitable in a constantly evolving environment.

Resilience, or Safety-II, holds that accidents should be understood as unexpected combinations or aggregations of simultaneous conditions and events which, by interacting with one another, produce uncontrollable outcomes and drive the system toward instability. As such, they are nonlinear phenomena that emerge unpredictably.

In this paradigm – referred to here as Resilience – adverse events occur when the system's ability to adjust falls short of the demands imposed by the context. From the resilience perspective, workers are seen as a fundamental source of system strength, in contrast to traditional approaches that regard people as sources of vulnerability. In Safety-I, humans are often viewed as unreliable elements, whose failures are blamed for the fragility of systems that, in their absence, would supposedly function flawlessly. However, as resilience research has advanced, it has become clear that people make a positive contribution to safety through their capacity to adapt in unanticipated situations.

Resilience represents a new way of thinking about safety in complex systems. Rather than focusing on what went wrong, it emphasizes understanding what goes right. Sources of resilience lie in the ability of workers to anticipate pathways that could lead to failure, to actively develop and maintain strategies sensitive to failure, and to preserve safety margins under pressure. Safe task performance is embedded – explicitly or tacitly – in both individual and organizational practices. Across their various roles, people remain alert to potential causes of failure and devise strategies to prevent them.

Errors emerge from the interplay of multiple factors. Neither work processes nor individuals intentionally choose failure; rather, the likelihood of failure increases when pressure prevents the development and support of safeguards and conditions for managing adversity – creating scenarios in which small variations can combine to produce significant consequences. From the resilience perspective, understanding how mistakes happen first requires understanding how success is achieved: how people learn, adapt, and create safety even in environments marked by gaps, risks, constant change, and sometimes conflicting goals.

Focusing on the day-to-day functioning of systems is essential for resilience and does not dismiss the importance of risk management approaches. Understanding risk factors is fundamental for planning mitigation and response strategies. As such, risk analysis and management are critical tools for addressing unwanted events – regardless of their severity – and must be grounded in the actual functioning of the system. This constitutes a crucial first step in grasping the dynamic context in which an unexpected public health event unfolds, directly informing strategies to strengthen the resilience potential of health systems. Without a proper analysis of the situation, it is unlikely that the responses will be appropriate.

In a given territory or population – particularly among the most vulnerable – disparities in the social determinants of health are key elements in risk analysis. Factors such as poverty, violence, inadequate sanitation and infrastructure, or the presence of populations with specific needs, such as Indigenous peoples, can significantly amplify the impacts of a disaster.

Conducting a comprehensive risk analysis requires strong partnerships and robust information-sharing capabilities. To support resilient performance, this analysis must be continuous, with all sectors involved maintaining up-to-date situational awareness of the evolving risk profile. Anticipating consequences within a complex system like public health is particularly challenging, as the interconnections among actors – crucial for effective analysis – can shift rapidly or even deteriorate. When carried out in this way, risk analysis becomes a valuable tool for understanding environmental and contextual influences and for developing contingency plans capable of addressing existing interdependencies.

> *Situational awareness is the perception of environmental and contextual elements and events, the understanding of their significance, and the projection of their future status. It also includes the awareness held by the actors involved in operating a system, relying on knowledge of a dynamic environment and guiding actions for carrying out activities within that environment.*
>
> *One of the key concepts of situational awareness is the distinction between the environment and a person (or system). Environment refers to everything that is happening around a person. The focus on important elements of the environment emphasizes that situational awareness is always about doing something within that system. This may be, for example, a task that requires interaction with relevant elements of the environment. Lack of or inadequate awareness of the situation has been identified as one of the main factors in accidents attributed to human error. (Endsley, 1995)*

When resources are limited or objectives conflict, safety is maintained not through predefined controls but through proactive adaptations to the unexpected – generating ad hoc solutions. Resilience challenges the assumption that safety can be preserved solely by adhering to prescriptions and that people are unreliable components of otherwise safe systems. It is not variability itself that demands constant adjustment; rather, acceptable and unacceptable outcomes both emerge from the same adaptive processes. In situations such as a sudden demand increase, equipment shortages, or understaffing, workers tend to respond proactively – adapting and taking control of the environment to enhance safety and efficiency. Whether these adaptations lead to resilience or fragility depends on the resources the system provides to support informed, well-grounded decision-making.

When Hollnagel, Woods, and Leveson (2006) proposed Resilience Engineering, they emphasized the need for a theoretical framework that foregrounds variability rather than error. The term "Engineering" – which often raises concerns among our public health students – signals the idea that systems can, in fact, be intentionally designed with a focus on resilient performance.

> *Safety-I is a perspective in which the notion of safety is based on the absence of accidents and incidents, or with an acceptable level of risk. In this perspective, safety is defined as a state in which as few things as possible go wrong and, when this happens, it is due to identifiable failures or malfunctions of specific components, such as technology, procedures or workers. In this conception, people are a liability or danger, mainly because they are the most variable of the components. Accident investigation is focused on the causes of adverse outcomes.*
>
> *Conversely, the so-called Safety-II perspective assumes that daily performance variability provides the adaptations needed to respond to changing conditions, and is therefore the reason why things work out. In health services, such as intensive care units (ICUs) or emergency doors,*

> *for example, the elements of work cannot be decomposed or described in detail for the system as a whole. Therefore, daily health work is adjustable and flexible. In these situations, improving safety depends on understanding how performance usually works, despite uncertainties, ambiguities and conflicts, to make the necessary adjustments. Humans are seen as a key resource for system flexibility and resilience. (Hollnagel; Braithwaite; Wears, 2015)*

Jens Rasmussen (1926–2018), a pioneer in the field of human factors, noted that "the role of the operator is to compensate for gaps in the work of designers" (Rasmussen, Pejtersen & Schmidt, 1990). This perspective highlights the gap between WAI and WAD, illustrating how individuals across different roles in a system develop effective strategies and adaptations to navigate complexity. Success, in this view, is achieved as people learn to adapt in ways that create and sustain safety.

A safety culture relies on remaining dynamically engaged in ongoing situational assessments to avoid outdated, narrow, or static understandings of context. Ultimately, safety is not a fixed or easily quantifiable variable – it is dynamic, shaped by variability, and reflects the system's capacity to confront and manage vulnerabilities.

Normal performance and failures are emergent phenomena, and unwanted events may arise not only from failures, but also when system adjustments are insufficient or inadequate. Building on this, Hollnagel emphasizes that failure is the reverse of success and cannot be explained simply by the malfunction of specific components or parts of the system. It is important to distinguish between normal performance and normative performance – the latter being what is prescribed in procedures and protocols. In contrast, normal operation emerges from the day-to-day adjustments required to navigate a dynamic and inherently variable environment.

The adaptability and flexibility of human work are what make it both effective and occasionally prone to failure – particularly in highly complex systems like universal public health systems, which are inherently difficult to fully specify. Normal actions succeed when people adapt to local conditions, technological limitations or idiosyncrasies, and shifting resources and demands. Failures occur when these adaptations go awry, even though both the individual actions and the underlying adjustment principles may have been sound. The true challenge for resilience lies in recognizing that complex systems are dynamic, and that a state of dynamic stability can shift into chronic instability – sometimes abruptly, as in an accident, or gradually, through the slow erosion of safety margins.

The sooner an adaptation is made, the easier it becomes to restore the conditions that existed before the disturbance. However, any adaptation aimed at mitigating negative variability may produce consequences that extend beyond its intended effects. If these consequences are minor and confined to a specific subsystem – such as a particular procedure within a health service – the likelihood of negative side effects is reduced, and resilience is thereby strengthened.

From an analytical perspective, improving resilient performance requires understanding how the system operates, rather than simply identifying what went wrong or pinpointing the causes of accidents. At the same time, it is essential to recognize what was unusual in each situation. Resilience – or more precisely, a culture of resilient behavior – is a property that depends on the interplay between the blunt end and the sharp end. By focusing on the tensions between these two ends, it becomes possible to avoid becoming stuck in crisis mode, since every effort to improve or respond generates new tensions. A strong example of this is seen in how SUS's territorial presence and capillarity – as part of an equitable, comprehensive, and universal health policy – intersect with the care coordination led by primary care.

When a permanent goal is framed as a value – such as longitudinal care – the focus shifts toward enhancing the system's ability to adapt general standards. The fundamental question for organizational design then becomes how large-scale systems can manage complexity, particularly the pace of change and the interrelationships among their subsystems. Failing to recognize or diagnose this complexity can cause significant harm to the system.

From a resilience perspective, organizations must recognize and avoid unnecessary sacrifices in pursuit of production and efficiency goals. Otherwise, under pressure – common in public health – people are more likely to adopt riskier behaviors. It is essential to respond promptly to early warning signs and address emerging issues. A policy that never allows production pressures to be relaxed in the face of such signs entails taking risks that may exceed safe limits. Conversely, reacting to uncertain warning signs may lead to unnecessary sacrifices, causing organizations to operate below capacity with reduced efficiency. Proactively managing risks and outcomes through resilient behavior requires the ability to identify the right moment to ease performance and efficiency demands – without increasing the risk of approaching safety thresholds.

Recent events, such as the deaths caused by COVID-19 – both among patients and healthcare workers – should prompt the development of new safety standards and legislation, as well as the establishment of professional bodies dedicated to improving worker safety.

These efforts should also support initiatives aimed at reducing work-related injuries and illnesses.

The major challenge at the blunt end is to develop guidance and provide resources that support people in making sacrifice judgments under conditions of uncertainty, while maintaining an acceptable level of calculated risk. It is precisely during periods of heightened tension that more sources of resilience are needed to sustain the balance between production demands and trade-offs. Achieving this requires enhancing the system's ability to discern critical situations and to dynamically align with decision-making criteria in uncertain environments.

In 1974, Ian I. Mitroff and Tom R. Featheringham introduced the concept of the error of the third kind to describe situations in which organizations address the wrong problem, thereby failing to respond appropriately to an event. Errors of the third kind represent failures of adaptation, occurring when people persist in applying familiar plans and responses to new circumstances – when what is actually needed are qualitative shifts in assessment, priorities, or strategies (Mitroff & Featheringham, 1974).

Conversely, adopting resilient behavior involves continuously monitoring strategies, adjusting and expanding actions to better accommodate shifting demands. The design focus of a resilient system should center on the organization's adaptive capacity in the face of potential challenges, with ongoing assessment of the risks associated with operating near safety limits. This monitoring must enable timely interventions to manage and recalibrate adaptive capacity as the system encounters new sources of variability.

Resilience involves assessing whether the system degrades more slowly when pressures exceed its adaptive capacity, and whether this is due to how the organizational context helps absorb or resolve these pressures, or to the adaptations made by local actors through alternative solutions or innovative tactics that influence broader strategic goals and interactions. All systems possess some level of resilience – when outcomes are negative, it may manifest as fragility, but such cases can also reveal the complex dynamics of hidden sources of resilience.

Organizations often fail to recognize or interpret signs of emerging vulnerabilities or ineffective measures until an accident brings them to light. While such events may lead to learning, the cost of losses can be very high, as the necessary post-accident changes involve a complex process of readjusting models. Resilience monitoring aims to track changes in conditions and the system's responses to uncertainty as clearly as possible, in order to detect unexpected disruptions. This enables organizations to focus on the right problems by identifying dynamics that erode resilience and lead to unnecessary increases in risk.

We are not suggesting that the Safety-II perspective should completely replace the traditional Safety-I approach. Rather, it is important to recognize that successful safety also relies on the variety of interprofessional practices that emerge from the diverse perceptions and perspectives of team members across different healthcare processes and contexts, each requiring distinct strategies. Safety-I and Safety-II represent two distinct paradigms for safety management, but they can coexist and be complementary – provided that managers possess the necessary knowledge to avoid undermining one approach in favor of the other, such as by prescribing protocols that are misaligned with the realities of the situation.

For certain repetitive, linear, and controllable activities, approaches that aim to limit variability and optimize resources – such as standardization and checklists – can be effective. In some specialized clinics, particularly those with high-volume systems and low variability, well-designed routines and strict work instructions prove successful. In these contexts, management tools based on standardization and rigid adherence to protocols function efficiently.

The COVID-19 pandemic has demonstrated that, in times of shocks or crises, few areas remain untouched by the need for adaptation. In many less predictable processes – such as those involving large multidisciplinary teams or patients with complex comorbidities – the imposition of safety barriers and rigid protocols can actually increase complexity. Rather than enhancing safety, these measures may undermine it, as the risks of excessively constraining performance in such contexts are well documented. These situations are better served by a non-linear, goal-oriented approach that allows practitioners the flexibility to adapt to dynamic conditions, rather than simply following rules automatically.

The concepts of resilience embodied in Safety-II offer a distinct perspective on patient safety and public health safety, highlighting the importance of acknowledging uncertainties and the necessity for ongoing adjustments in daily work – along with its successes and failures. Its value lies in offering a deeper understanding of the skills that create and reinforce safety, aligning more closely with the complexity of work-as-done.

Summary

In this chapter, we connect the concepts and principles of Resilience Engineering to the functioning of health systems broadly, and the SUS in particular. Perhaps the most significant contribution of Resilience Engineering to industrial systems – especially those managing high risks – is the demonstration that unwanted outcomes, including accidents, emerge from normal operations due to the interplay of variabilities that go unidentified or unmonitored by the system.

This idea highlights the importance of analyzing and understanding normal functioning – not as adherence to prescribed standards, but by observing how work is actually carried out on a daily basis, known as Work-as-Done (WAD). Building on this, we have seen how the Safety-II perspective on safety in complex systems has been applied in health systems to analyze accidents, adverse events, health risks, and more.

We also observe that maintaining structures or functions related to resilience – such as preparedness, robustness, redundancies, and in-depth defenses – does not, by itself, guarantee resilient operation during disasters. In Resilience Engineering, these structures and functions must be coupled with capabilities or skills essential for resilience, including anticipation, response, monitoring, and learning.

In the next chapter, we will explore health emergencies and how health systems are increasingly leveraging health surveillance to enhance resilient performance.

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Chapter 7

Health Emergencies and Everyday Resilience

Resilience is consolidated by the need to minimize health risks caused by extraordinary or regular events, regardless of their intensity or frequency.

It is important to note that resilience does not require the occurrence of an acute event to manifest. On the contrary, especially in public health, numerous events of varying intensity occur on a daily basis, and the resilience of health systems lies in their continuous readiness to respond.

In the face of conditions that threaten public health, local health authorities may declare health emergencies independently of national declarations. These declarations vary across countries but often apply to specific geographic or sanitary areas that do not necessarily correspond to political boundaries. In certain situations, the measures adopted by government authorities at different levels may extend beyond the health sector, including social distancing, closure of businesses, restrictions on movement and gatherings, among others.

The declaration of a health emergency also entails the activation of an alert system, which is triggered based on the evolution of the monitored event. This system defines the actions, measures, and responsibilities to be undertaken by personnel and institutions, ensuring that the public is informed about the necessary actions and protective measures. Communication in such contexts targets multiple audiences and serves various purposes – from providing guidance to health professionals to disseminating timely information to emergency response teams.

As situational awareness evolves, decisions about how to communicate must be made in coordination with various actors, enabling the mobilization of critical resources to support an effective response. In the context of public health system, communication is also closely tied to the system's ability to collaborate with civil society actors. Community engagement plays a vital role in strengthening the capacities that underpin resilient performance.

An effective public communication system must be designed to enable communities to actively contribute to the health system's resilience potential. According to the World Health Organization (WHO), community engagement is the foundation of resilience in the face of severe public health events. A notable example is the WHO's framework developed in response to the 2013-2015 Ebola outbreak in Africa, which highlights the critical role of community adherence and participation in strengthening system responsiveness (World Health Organization, 2017).

Based on these ideas, the political agendas of public agents at all levels of government must be aligned – or at least consistent – with the objectives of the health system. When conflicting goals arise between public authorities and health services, as occurred during the response to COVID-19 in Brazil, the system's ability to respond becomes fragile, often leading to catastrophic outcomes for the population.

Networks, relationships, and collaborative processes that enable effective communication must be recognized as integral components of the complexity of health systems – and as essential elements for resilient performance. Likewise, adaptive capacity and communication are mutually reinforcing. When information and communication are lacking or unreliable, individuals will seek alternative channels to obtain the information needed to carry out their tasks.

It is not only infectious disease outbreaks that pose risks to populations. Various events – both direct and indirect – can significantly affect health, particularly in the context of increasingly frequent and extreme climatic phenomena. Recent examples include hurricanes in the United States and Vietnam (2024), severe heatwaves in Japan, Australia, Iran, and Mali (2024), and record-breaking floods in Italy. Other disruptive events include the resurgence of diseases, the emergence of new outbreaks and epidemics – as seen in the recent COVID-19 pandemic – as well as conflicts, wars, chemical and radiological incidents, infrastructure failures, transport accidents, energy supply disruptions, air pollution, climate change, and prolonged droughts. These events differ in scale, frequency, and onset: some are sudden and rare, while others unfold gradually over extended periods. Small-scale events with limited consequences occur regularly, whereas others escalate into emergencies or catastrophes with major impacts on public health, well-being, and long-term health development.

Although disaster and emergency risk management is one of the essential public health functions identified by PAHO, its incorporation into the functional inventory of health systems remains limited – even within Brazil's Unified Health System (SUS). Carlos Machado de Freitas, Simone Santos Oliveira, and Christovam Barcellos, professors at the Sergio Arouca National School of Public Health (ENSP), note that while disasters are inherently interconnected phenomena, they are often addressed through distinct epistemological lenses and treated as if they result solely from technological failures or natural events

(Freitas; Oliveira; Barcellos, 2021). In many cases, disaster recovery efforts prioritize economic losses and environmental impacts, often at the expense of the health-related dimensions involved.

The health, economic, political, and social consequences of such events can be devastating. Phenomena such as climate change, unplanned urbanization, population growth, and migration, among others, have been occurring with increasing frequency and intensity worldwide, placing growing pressure on health services. For instance, under the International Health Regulations (IHR), a Public Health Emergency of International Concern (PHEIC) is defined as an event that meets a combination of four criteria:

- Severity;
- Unpredictability;
- Possibility of international spread;
- Need for restrictions on movement or economic activity, focusing on people's health.

The IHR constitute a legally binding international instrument adopted by 196 countries, including all WHO Member States. Their primary objective is to assist the global community in preventing and responding to serious public health risks that may cross borders and pose threats to populations worldwide. Public Health Events (PHEs) refer to manifestations of diseases or other occurrences with the potential for widespread dissemination, including risks to both individual and public health. In addition to communicable diseases, PHEs encompass health threats arising from technological or industrial disasters (e.g., chemical, oil, or nuclear incidents) as well as those resulting from climate-related events.

In the globalized era in which we live, the intense movement of people and goods across borders significantly increases the potential for the spread of communicable diseases – an effect intrinsically linked to current social and economic dynamics. The world is undergoing transformations on multiple fronts, all of which impact public health in various countries and influence people's daily lives, often in ways that go unnoticed. This context underscores the critical need for early detection, reporting, and recognition of significant changes in the occurrence patterns of infectious diseases or in the transmission dynamics of their agents. As a result, there has been growing reflection on the factors involved in the processes of disease monitoring and control.

The notion of disaster as a socially constructed event is particularly relevant to resilience in public health, where adaptability is most evident in the interaction between health workers and users. In his seminal work *The Human Side of Disaster*, Thomas E. Drabek laid the foundation for the field of Disaster Sociology, making a significant contribution to our understanding of how individuals, groups, organizations, and communities prepare for, respond to, and recover from disasters of all kinds – with a particular emphasis on human and social dimensions.

From the perspective of Disaster Sociology, emergency management must aim to identify and reduce uncertainties inherent in potentially hazardous situations, while maximizing public safety and minimizing the costs associated with emergencies or disasters. This is achieved through the implementation of a range of strategies and tactics that address the entire life cycle of such events – preparation, response, recovery, and mitigation (Drabek, 2018).

Drabek offers a conceptual framework composed of perspectives, concepts, and methods that define the field of Disaster Sociology, notably distinguishing between disasters and threats. In this approach, a disaster is characterized as an event in which a community experiences severe human and material losses, exceeding its available resources. In contrast, a threat refers to a condition that carries the potential to cause harm to the community or the environment. From a sociological standpoint, the term disaster denotes an actual event, whereas threat refers to a category of events – such as hurricanes, fires, or earthquakes – that may occur in a given region. Accordingly, one might refer to the threat or danger of fire, for example, to describe a high-risk situation shaped by the community's level of vulnerability or exposure.

Norma Valencio, founder of the Center for Social Studies and Research on Disasters at the Federal University of São Carlos (UFSCar), highlights the relationship between scientific approaches to disasters and authoritarian or militarized cultures. From this context emerges the overemphasis on the theory of hazards and a technocratic perspective – positions that the Sociology of Disasters explicitly challenges. According to Valencio, the theory of hazards privileges a geographical lens, focusing primarily on physical mechanisms, spatial and temporal distribution, and the dynamics of physical event occurrence. In contrast, the Sociology of Disasters centers on complex social organization and collective behavior as key elements in understanding disaster processes (Valencio, 2014).

Strengthening the resilient behavior of health systems in response to such events is also essential for advancing the Sustainable Development Goals (SDGs), particularly in promoting universal access to health and enhancing "the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks" (UN, 2017). In this context, health systems play a critical role in risk management and in reducing the impacts of both routine situations and sudden events – even though their role in addressing infectious disease risks and responding to outbreaks is more readily recognized. The health sector has a fundamental responsibility in preventing and mitigating the health consequences of all types of emergencies. To fulfill this role, it must be fully integrated with communities and coordinated with other sectors of activity.

The impacts of health emergencies extend far beyond increased morbidity, mortality, and disability. They can lead to service disruptions, the collapse of health facilities, interruption of programs, workforce losses, and system overload. The financial costs are also staggering. According to the World Health Organization (WHO), emergencies caused by natural and technological hazards cost an estimated US$300 billion per year, while the costs of armed conflicts can reach trillions. The expected annual losses from pandemic risks – due to impacts on productivity, trade, and travel – are estimated at around US$500 billion, equivalent to 6% of global annual income.

Most countries are likely to face a large-scale emergency approximately every five years, and many are regularly exposed to recurring hazards such as floods, cyclones, and disease outbreaks. While major disasters tend to attract international attention, hundreds of smaller-scale emergencies and hazardous events – such as outbreaks, floods, droughts, fires, and transportation accidents – occur every year. Cumulatively, these events account for a significant number of deaths, injuries, illnesses, and disabilities (World Health Organization, 2019).

The strengthening of health systems, the implementation of IHR and the development of disaster risk management strategies, together with increased attention to climate change, are common challenges for all, which reinforces the idea that resilience is a property that must be developed daily, and not only when acute and disruptive events occur. The ability to mitigate the effects of health events is hampered by fragmented approaches to different levels of events, often causing an imbalance in strategies, with excessive emphasis on reaction to the detriment of prevention and preparation.

Given the current and emerging risks to public health and the growing need for more attentive and responsive management, resilience is increasingly recognized as a critical attribute to be embedded in policies, strategies, and programs. Its incorporation is essential to minimize both direct and indirect health risks arising from extraordinary events, regardless of their intensity or frequency. Such policies and strategies should be multidisciplinary, cross-sectoral, and grounded in comprehensive approaches.

Following a shock, resilience should not be confined to the early recovery phase. It plays a crucial role in reducing response time, fully restoring essential services, and enabling the resumption of routine activities. To achieve this, early recovery strategies must be planned by public authorities in collaboration with civil society and, often, with active community participation – throughout both daily operations and during sudden events. Strengthening the system's capacity to foster a culture of resilience is therefore essential. This involves moving beyond the notion that disasters are the primary opportunities for understanding risk. Instead, it requires continuous analysis of the factors that caused or exacerbated adverse events, with the goal of improving conditions before new crises emerge.

In today's world, organizational systems are consistently expected to perform beyond their capacity. As a result, achieving all proposed goals is not always feasible, particularly given the limited resources available to public entities responsible for safeguarding population health. According to David Woods, one of the founders of the Naturalistic Decision-Making paradigm, any advancement – such as the introduction of new technologies – is quickly leveraged to push systems toward greater intensity and increasingly complex activities, often under heightened pressure and without a corresponding investment in resources (Woods, 2003).

The constant pressure for systems to operate faster, better, and at lower cost drives the introduction of changes that may bring not only new capabilities, but also new vulnerabilities. The ability to recognize and manage these trade-offs and tensions in the context of change – while maintaining system functionality – is essential. In this process, ensuring adequate care for individuals remains a fundamental element of resilience management within health systems.

Resilience-oriented health surveillance

One of the hallmarks of resilient performance is the ability to monitor threats – enabling anticipation of potential events and the generation of timely responses. Monitoring not only supports immediate action but also contributes to building knowledge about threats and developing the skills necessary to manage them. In this regard, Alexander Langmuir (1963, p. 182) proposed a contemporary definition of health surveillance that moved beyond the outdated notion of merely observing sick individuals. His concept, still relevant today, aligns closely with the principles of health system resilience:

> *Continuous observation of the distribution and trends of disease incidence through the systematic collection, consolidation and evaluation of morbidity and mortality reports, as well as other relevant data, and the regular dissemination of this information to all who need to know it.*

The concept of epidemiological surveillance, which remains relevant today, was soon after proposed by Karel Raskà. Widely adopted in the field of public health, his approach gave surveillance a broader scope – extending it beyond infectious diseases to include other adverse events that directly or indirectly affect population health (Raskà, 1966).

As a typical resilient mechanism, health surveillance is often associated with effective responses to extraordinary events – such as disease eradication campaigns carried out in Brazil at various points in history, even before the creation of the SUS. Disease notification systems, present in all health surveillance agencies, are key tools for anticipation. They also serve as mechanisms for monitoring population health, issuing alerts, and maintaining situational awareness – capabilities that are central to resilience. These include both formal surveillance systems, such as occupational health surveillance, health surveillance, environmental surveillance, and epidemiological surveillance.

Situational awareness is a vital source of information for identifying emerging risks, enabling early warnings by public health authorities. This applies to both local and external – or even global – contexts, as events in other parts of the world can impact the local environment, as demonstrated by the COVID-19 pandemic. To foster resilience, surveillance and situational awareness must connect the different parts of a complex system through comprehensive communication and refined risk analysis, in alignment with the collaborative nature of Health Care Networks (HCNs).

When supported by digital tools – such as epidemiological intelligence systems – surveillance structures are organized to receive information in real time, for example, through automated analysis platforms.

This enhances the ability of health services to respond by reducing the time between the occurrence of an event and the implementation of control measures. Such agility is essential not only for protecting population health but also for preserving the socioeconomic and institutional stability of affected cities and regions.

Another central aspect of modern health surveillance is the integration of Community-Based Surveillance (CBS), which significantly expands the reach and sensitivity of formal surveillance systems. By directly involving community members in identifying, reporting, and responding to unusual events or health issues, CBS fosters a collective sense of ownership and strengthens the connection between the population and health services. This participatory approach enables more contextualized, inclusive, and sustainable responses – particularly in areas of social and institutional vulnerability. Moreover, community engagement helps identify local patterns, allowing for more precise and culturally appropriate interventions.

Health surveillance plays a strategic role in strengthening the resilience of health systems by enabling the anticipation of risks and preparation for future threats. The use of epidemiological models, predictive algorithms, and early warning systems provides managers and policymakers with qualified information for decision-making in uncertain contexts. Particularly important is the ability of these systems to collect data on vulnerable populations – such as pregnant women, children, older adults, and individuals with chronic conditions – to inform both clinical guidelines and more equitable prevention strategies. By combining technology, social participation, and epidemiological intelligence, health surveillance is established as a key component of health system resilience, making a decisive contribution to protecting lives during health crises.

In Brazil, the reorganization of the epidemiological surveillance system began to take shape in the 1990s, alongside the more effective implementation of the SUS. During the same period, a proposal for health surveillance was developed, structured around three main lines of action:

- Monitoring of health effects, such as health problems and diseases. This first component, sometimes considered synonymous with Health Situation Analysis (HSA), broadens the scope of epidemiological surveillance but does not encompass actions aimed at addressing the identified problems;
- Monitoring of potential threats, such as chemical, physical, and biological agents that may cause diseases and health problems. This perspective views health surveillance as an integration of epidemiological and sanitary surveillance, leading to administrative reforms and, in some cases, the strengthening of territorial actions and coordination with health units;
- Exposure surveillance, through the monitoring of individuals or population groups exposed to an environmental agent or to its effects that are not yet clinically apparent.

Health surveillance is understood as a redefinition of sanitary practices, organizing health work processes into operations that address problems requiring continuous attention and monitoring. It encompasses occupational health surveillance, health surveillance, environmental surveillance, and epidemiological surveillance. In this model, the focus shifts from disease itself to the conditions and ways of life of the population, enabling territorial interventions on a broad range of issues that demand ongoing attention. This shift strengthens the health system's capacity to remain continuously prepared for extraordinary events, thereby enhancing its resilience. It is also within the framework of health surveillance that the concept of risk in the field of public health is further developed.

> *According to PAHO (1999), Health Situation Analysis (HSA) is a process that allows to characterize, measure and explain the health-disease profile of a population, including damages, problems and determinants of health, in order to identify the needs and priorities, interventions and health programs corresponding to a given population space, producing useful and valid information about the population of a given territory to guide action and decision-making in collective health, as well as to strengthen social control.*

The Pan American Health Organization (PAHO) developed the STAR-H methodology as a strategic tool to enhance risk management capacity in public health emergencies and disasters across health facilities of varying sizes and levels of complexity. Its primary objective is to support managers and professionals involved in emergency planning and response by systematically identifying and assessing risks. This process enables the creation of historical records and risk profiles at national and subnational levels, which can be integrated into strategic planning. The methodology supports the development of comprehensive response models, with clearly defined standard operating procedures for managing adverse events – regardless of their nature, magnitude, or frequency. Additionally, it provides guidance for assigning institutional roles and responsibilities, optimizes the use of available resources, promotes simulated planning exercises, and significantly contributes to improving the preparedness of health services.

Ultimately, STAR-H plays a key role in supporting the formulation and implementation of robust health risk management programs aligned with the principles of institutional resilience and the coordinated, effective response to health emergencies.

One of the key initiatives for operationalizing the concept of health surveillance in Brazil – with notable effects on the resilience of the health system – is the Strategic Information Center for Health Surveillance (CIEVS). Implemented in 2005 by the Ministry of Health, the CIEVS was established to enhance the country's response to public health events. It also serves as Brazil's focal point for the International Health Regulations (IHR), with the responsibility of responding to World Health Organization (WHO) information requests within 24 hours.

Currently, the CIEVS are part of the National Network for Monitoring, Alert, and Response to Public Health Emergencies, operating through 54 active centers across Brazil. Moreover, some local health departments have appointed health professionals to serve as CIEVS Focal Points within each health region. These professionals act as sentinels for public health events, thereby expanding the system's capacity to detect emergencies.

In investigations, identifying the causative agent and associated risk factors – and adopting timely prevention and control measures – is only possible when suspected cases are reported immediately. Waiting for laboratory confirmation is not required. Integration among public and private health professionals, Municipal and State Health Departments, and the Ministry of Health is essential to ensure the prompt implementation of control and prevention actions.

From its establishment until the 2016 Olympic and Paralympic Games, the CIEVS played a central role in monitoring and coordinating responses to major public health emergencies (PHEs), including H1N1, Zika, Chikungunya, Yellow Fever, and Measles. It also led the coordination of health actions during major mass gatherings hosted in Brazil, such as the Military World Games, Rio+20, the Confederations Cup, the FIFA World Cup, and the Olympic Games.

This context influenced the development of public policies aimed at building participatory surveillance systems, incorporating tools for the digital detection of diseases. This innovative approach to epidemiological surveillance engages communities directly, offering several advantages: reduced costs for data collection, faster acquisition and sharing of information, platform scalability, and stronger integration between the population and public health services.

Even in the aftermath of the COVID-19 pandemic, there remains significant difficulty in advancing a model of health surveillance that is not solely focused on disease. Although important progress has been made in Latin America – particularly through more socially oriented approaches to surveillance – government actions continue to center predominantly on biomedical technologies in health, often neglecting the broader political and social contexts of each country.

Summary

In this chapter, we have seen that, beyond the pursuit of the so-called "Holy Trinity" of universality, equity, and integrality – as well as the improvement of its decentralized structure and the emphasis on primary health care (PHC) – any universal health system must also be equipped to respond to health emergencies, and the SUS is no exception.

The role played by the Strategic Information Centers for Health Surveillance (CIEVS) – structures that enable essential functions to address increasingly severe public health events (PHEs), such as the epidemics and pandemics witnessed in the early 21st century – is fundamental to the resilience of the SUS.

In the next chapter, we will turn to the topic of health planning, exploring how plans and guidelines – prescriptions and projections of future conditions – can incorporate elements of resilience.

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Chapter 8

Contributions to Health Planning and Management

Planning for resilience requires moving beyond prescriptions. It involves the development of adaptive, absorptive, preventive, and transformative capacities.

A well-established field such as Health Planning can also benefit from the concepts and tools offered by approaches related to the resilience of complex systems. Widely adopted frameworks, such as the planning cycle, can incorporate innovative tools and methods, thereby generating new outcomes across various levels of health organizations – from management to service delivery, from the blunt end to the sharp end.

Resilience in public health has emerged as a strategic and guiding concept for public health management and planning, particularly in a global context marked by recurring health crises, climate change, conflict, and social inequalities. More than simply the capacity to withstand shocks, resilience refers to the ability of health systems to prepare adequately, respond in a coordinated and effective manner, maintain essential functions during crises, and – above all – learn from these experiences to drive institutional change and continuous improvement. This perspective transforms the way policies and organizational arrangements are designed, incorporating uncertainty as a permanent element of the planning process.

From a health management perspective, resilience significantly contributes to strengthening governance capacity by demanding prepared leadership, agile decision-making structures, and integrated information systems capable of functioning under pressure and in highly complex contexts. It also fosters intersectoral integration and community engagement, enhancing both the legitimacy and effectiveness of health interventions. Coordination across levels of care, collaboration with other sectors of government, and active listening to communities have become central to addressing crises in an equitable and efficient manner. Moreover, resilience informs the design of more flexible institutional arrangements, enabling processes and workflows to be reconfigured in response to emerging needs without compromising continuity of care.

In health planning, resilience offers conceptual and operational tools for incorporating risk and uncertainty into public policy formulation. It guides the rational use of resources, prioritizes vulnerable populations, and strengthens local capacities. The predictability of events – through modeling and intelligent monitoring – combined with flexible financing mechanisms, enables rapid and sustainable responses. Moreover, the recognition of human capital and the strategic management of human resources – with an emphasis on supporting, training, and valuing professionals – have become essential components of health systems that aim not only to withstand crises, but to emerge from them stronger, more inclusive, and better prepared to confront future challenges.

There is no antagonism between planning – which involves constructing projections and establishing guidelines – and resilience, which requires creating spaces for the adaptive functioning of health systems. Resilience does not imply disorganized adaptation; on the contrary, it entails structured and intentional flexibility.

Several public health advocates – such as Jairnilson Paim, Emerson Merhy, Elizabeth Artmann, and Carlos Matus, among others – have dedicated themselves to this theme. The challenge lies in overcoming the persistent notion, still present in some health sectors, that planning constrains the system's ability to adapt to extraordinary events. In contrast to this view, the authors mentioned above have advanced a less normative and more formative approach to Health Planning, incorporating concepts that strengthen the resilient capacities of the SUS.

At first glance, planning may appear incompatible with resilience. After all, planning involves prescribing a set of actions to be carried out, which might seem, in theory, contrary to the need for adaptation in the face of the unforeseen. As previously discussed, excessive prescription tends to limit resilient capacity – especially because, in complex systems, prescribed work rarely corresponds to what can actually be performed. This does not imply, under any circumstances, that prescriptions should be eliminated from health work. On the contrary, when not excessive, prescriptions are essential for establishing the fundamental guidelines of action. The key is to avoid making them restrictive, thereby preserving the adaptive capacity of workers in environments where variability is inherent, such as public health. In other words, the creation of formal spaces for adaptation can – and should – be planned.

It bears repeating: resilience does not, in any way, mean hastily improvised solutions. Rather, it refers to preserving flexible spaces that allow workers to adapt within a variable and often unpredictable context – one that exceeds the limits of traditional planning. Coordinated actions can and should be planned to reinforce positive adaptations in daily practice, while identifying and discarding those that are ineffective or detrimental.

Planning is essential for defining roles and responsibilities and for understanding organizational structures and functions, thereby contributing to greater efficiency in preparing for and responding to unexpected events. It is through the planning process that the tools and resources necessary for an effective response are identified. This is a complex task, given the multiple influences and interdependencies involved in public health emergencies. When scenarios shift, these interdependencies generate ripple effects that impact other parts of the system. Understanding these dynamics provides critical information for adapting to both anticipated and unforeseen events. Therefore, planning must be continuously updated, as a system's capacity to adapt depends on the availability of resources, enabling conditions, and contextual knowledge.

The variability inherent in the public health context should not be underestimated – nor should the importance of planning for resilient performance. The ability to anticipate can be decisive, particularly in the face of events that unfold less abruptly but are prolonged and highly disruptive, such as financial crises, shifts in political arrangements, or the implementation of austerity programs. To underscore the value of planning, it is helpful to revisit the distinction between disaster and threat, as discussed in Chapter 7. Preparing for a threat represents the final critical opportunity to prevent a disaster or mitigate its effects. In this sense, preparing for an eventual crisis is often more feasible than preparing for a full-scale disaster. However, as previously noted, lower-intensity events occur routinely and carry significant disruptive potential. The traditional, retrospective, error-focused approach to safety often hinges on how a crisis is managed. Thus, it is essential to distinguish between mere preparedness and planning that results in concrete mitigation actions.

Mitigation actions must also be planned; in general, they aim to prevent crises by reducing the likelihood of an event occurring, diminishing its intensity, or decreasing the vulnerability of the health environment. For example, in the case of vector-borne disease outbreaks, a mitigation action might involve home visits to eliminate breeding sites – a strategy employed by the SUS in response to dengue since the early 1980s. Mitigation improves the system's preconditions for dealing with disasters, making such events less likely or less severe, though not entirely preventable. In contrast, maintaining a state of preparedness focuses on strengthening the capacity to manage threats and crises, thereby preventing them from escalating into disasters.

Mitigation processes and preparedness must be planned and activated on a daily basis, as they are essential components of resilient performance. However, the knowledge required to mobilize each of them is quite distinct. Mitigation actions are deeply embedded in health service planning – for example, through risk assessments and regionalization strategies, which enable the anticipation, identification, and classification of local aspects that require continuous monitoring due to their potential for deterioration.

Unlike mitigation, maintaining preparedness involves planning and executing activities prior to a crisis that enhance the system's capacity for absorption and/or response to disruptive events. The key challenge for planning in such cases lies in the fact that the specific conditions of a future crisis cannot be fully anticipated.

Classical Health Planning theory gained prominence in Latin America during the 1960s, influenced by the developmental perspective of the Economic Commission for Latin America and the Caribbean (ECLAC).

The notion of integrated development served as the discursive backdrop for the emergence of Health Planning, particularly through the work of the Venezuelan Development Center (CENDES), an agency of the Central University of Venezuela supported by the Pan American Health Organization (PAHO).

The CENDES-PAHO method, a seminal reference in the field of Health Planning, was originally centered on resource programming through the integration of cost-benefit analysis techniques and the hierarchy of potential health damage caused by public health emergencies (PHEs). Within this approach, events associated with lower relative costs are naturally prioritized in planning, in order to ensure scheduling efficiency. However, the method presents limitations when faced with the typical variability found in the governance conditions of the health sector – such as institutional and policy instability, financing challenges, service coordination, and the role of private market actors. On the other hand, the method does provide a certain rationality for planning the costs of prevention, response, and recovery actions related to PHEs.

An evolution of the CENDES-PAHO model can be seen in the proposal of the Pan American Center for Health Planning, which emphasizes planning as a supporting element in the implementation of public policies. According to this approach, health planning is a process led by the State that involves the coordination of multiple actors and, therefore, depends on strategic direction and political feasibility (Durán *et al.*, 1965; Rocha, 2011). Nonetheless, the issue of an overly normative approach persists, which restricts adaptive spaces and, consequently, undermines resilience.

Carlos Matus offers a counterpoint to normative planning in health by introducing the principles of strategic planning, grounded in theories of the situation, social production, and interactive action.

This approach results in a problem-processing protocol composed of four phases:

- Explanatory;
- Normative;
- Strategic;
- Tactical-operational.

Matus's proposal, known as Strategic-Situational Planning, incorporates elements of scenario prospecting and strategic analysis tools, supporting the development of resilient capacities such as anticipation and organizational learning. For Matus, planning is "the calculation that precedes and presides over action" (Matus, 1987, p.153):

> *(...) think before acting, think systematically, with method; explain each of the possibilities and analyze their respective advantages and disadvantages; propose objectives. It is to project yourself into the future, because today's actions will have been effective, or ineffective, depending on what may happen tomorrow and what may not happen.*

Mario Testa, who was part of the group that developed the CENDES-PAHO model, also makes his contribution to overcoming the normative model of health planning. He formulated a proposal to analyze epidemiological and organizational problems through the lens of strategic planning, introducing the concepts of administrative, strategic, and ideological diagnoses of the health sector. Testa advocated for a form of planning less focused on political formalization and more oriented toward communication. Within this theoretical framework, planning is understood as “dialogical practices in the service of establishing consensus and agreements on commitments, more flexible and less structured” (Durán *et al.*, 1965).

Another outstanding work is that of Gillings and Douglass (1973, p. 7), who propose a spiral cycle of planning in four stages, illustrated in Figure 1:

- Analysis of the problem or diagnosis of the situation;
- Defining objectives;
- Selection of the best methods/techniques to achieve the objectives;
- Evaluation.

The establishment of a formal planning cycle allows for the identification of specific management tools appropriate to each phase. In this context, it becomes easier to incorporate tools typical of Resilience Engineering – such as techniques for modeling and analyzing variability, or instruments for assessing learning potential, anticipation, monitoring, and response. These tools are well established in the resilience literature and will be explored in more detail later.

In the planning cycle proposed by Gillings and Douglass, the problem analysis phase emphasizes not only identifying causes but also recognizing the resources available within health services to support resilient behavior. Rocha (2011) reinforces this perspective by suggesting that programming should incorporate an analysis of the health sector itself as part of the diagnostic process. This includes, for example, identifying morbidities alongside an assessment of available resources – such as health professionals, hospital beds, laboratories, funding, and other structural components.

The determination of priorities and objectives must also take into account the diverse political and technical interests that shape the organization of health programs. In Brazil, this principle is reflected in the participatory role of various councils, such as the National Council of Health Departments, the National Council of Municipal Health Departments, and the Municipal Health Councils. The aim is to develop resilient capacities that are aligned with local realities and whose implementation is feasible from both organizational and financial perspectives.

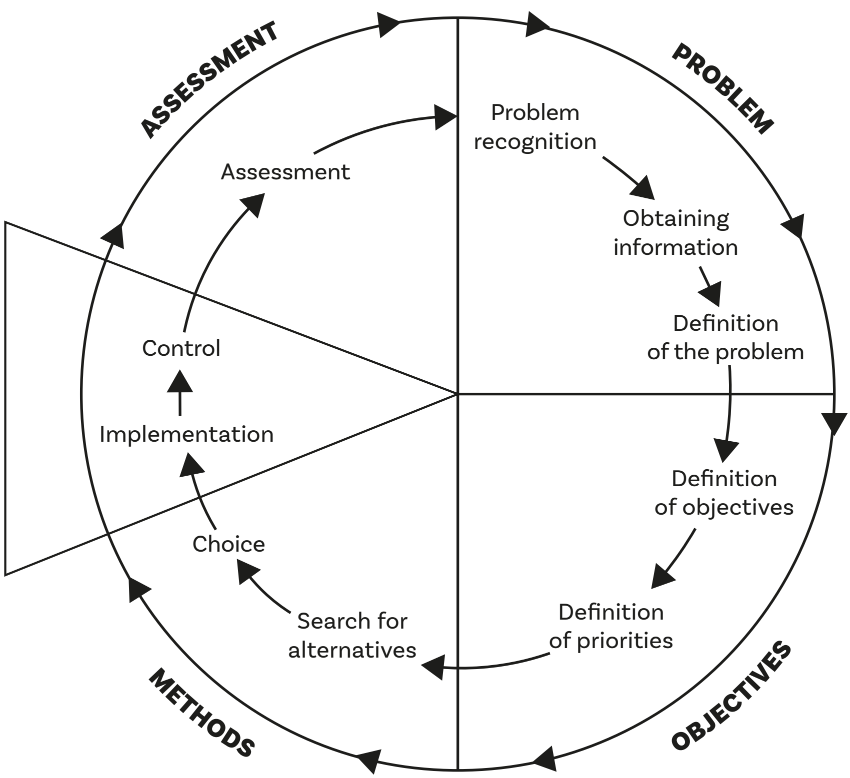

Figure 1: Planning Cycle.
Source: Adapted from Gillings and Douglass (1973).

Within the Brazilian legal framework, planning is established in the Organic Health Law, which assigns to the national management of the SUS the responsibility to "prepare national strategic planning [...] in cooperation with states, municipalities, and the Federal District" (Brasil, 2005a). Furthermore, Law No. 8,142 of 1990 stipulates that access to resources from the National Health Fund (FNS) by states and municipalities is conditional upon the submission of health planning and management reports. These instruments allow the Ministry of Health to monitor resource allocation and assess its alignment with established programs. The Pact for Health identifies the following priority areas for SUS planning:

- Adoption of the population's health needs as a criterion for the planning process;
- Integration of planning instruments;
- Institutionalization and strengthening of the sus Planning System, including monitoring and evaluation;
- Review and adoption of a list of planning instruments;
- Cooperation between the three management spheres for strengthening and equity in the planning process.

The instruments of the SUS Planning System include the Health Plan, the Annual Health Program, and the Annual Management Report. All are guided by situational analysis and the formulation of objectives, guidelines, and targets, taking into account the population's health conditions, the social determinants and conditions of health, and the performance of health management.

Monitoring the population's health conditions is based on the analysis of its demographic, socioeconomic, and epidemiological profile.

The evaluation of health determinants and conditions seeks to identify intersectoral actions developed within different levels of government that shape the health status of populations. This evaluation is essential for integrating the health sector with other arenas of public policy formulation – such as Science and Technology, the Judiciary, Education, and others.

Health management, in turn, encompasses decentralization, regionalization, financing, social participation, workforce and health education management, infrastructure, and health information systems (Rocha, 2011).

The tools employed for analyzing complex systems are not only compatible with but also beneficial to the health planning process. For instance, analyses of potential variability can inform the allocation of resources, or the development of contingency plans. Similarly, retrospective analyses of variability in the execution of public health functions can enhance the detail and quality of management reports, offering decision-makers more precise information on how the SUS exercised its daily adaptive capacity or responded to serious and unforeseen events during a given period.

In Part II, some of these tools will be presented, along with demonstrations of their application in selected scenarios within SUS services. It will be the reader's task to assess the potential integration of these tools into the current SUS Planning and Management framework.

Finally, planning for resilience must go beyond prescriptive approaches and contribute to the functioning of cognitive and organizational systems within environments that offer the necessary resources to develop resilient capacities – such as adaptation, anticipation, monitoring, response, and learning.

The dilemmas of measuring resilience

As resilience becomes more evident at the sharp end – where care is delivered – it must nonetheless be cultivated throughout the entire health system. This raises a common question: how can the resilience of a public health system like the SUS be measured? While it is not impossible to speak of the resilience of the SUS as a whole, it is often more feasible to describe the resilience of a specific service or program. A more complex aspect of this question concerns how to assess the system's potential to develop resilience – especially if resilience is understood as a property built daily, akin to a culture. How, then, can one establish metrics to evaluate the capacity of public and universal health systems for resilient behavior? Are there primary functions, structures, or indicators that support the potential for resilience?

This issue remains unresolved, although recent literature presents several promising initiatives in this direction. Like resilience itself, its assessment is an evolving field – particularly with regard to quantitative approaches. Just as we have sought to present resilience as a dimension of Health Planning, it is also possible to explore its incorporation into the field of Health Monitoring and Evaluation, another well-established area in Public Health. This integration can be highly valuable for understanding resilience as an attribute of the SUS, one whose quality should be assessed using formal methods – whether qualitative, quantitative, or mixed. In fact, the longstanding debate over the superiority of quantitative versus qualitative methods is unhelpful in the context of resilience and is increasingly considered outdated, given that both approaches have well-recognized strengths and limitations.

This does not imply overlooking the fact that resilient performance will always depend on human actions and cognition. On the contrary, the concept of a system designed to support resilient performance includes both structure and resources – that is, the health system must enable individuals to develop and apply the skills necessary for resilient action.

Resilient performance relies on a culture that must be cultivated daily through the system's operation. Resilience is expressed in how the system functions with the resources it has at its disposal. It is essential to recognize that structure and functioning are mutually dependent and inherently complementary – they should not be viewed as paradoxical. For this reason, rather than introducing entirely new and isolated approaches, resilience tools can be incorporated into the methodological frameworks already used in public health systems management. Similarly, established management tools can contribute to the blunt end when reoriented toward resilient performance. The shift lies not in the tools themselves, but in the purpose of their application – in this case, the pursuit of increasingly resilient performance. Some practical experiences along these lines will be presented in Part II of this book.

In the specific case of evaluation, this is a practice found across various areas and fields of the social sphere. Some authors argue that this diversity of expression leads to conceptual and methodological polysemy, making it necessary to adopt specific techniques tailored to health management (Champagne *et al.*, 2011; Hartz & Contandriopoulos, 2004; Hartz & Vieira-da-Silva, 2005).

André-Pierre Contandriopoulos is one of the leading scholars in the field of Health Evaluation, arguing that the formulation of public health policies should be grounded in evidence produced by evaluative research. This research, in turn, should inform decision-making regarding the assessment of an intervention or any of its components. Although widely accepted, this perspective is not without criticism. For example, Lígia Maria Vieira-da-Silva, professor at the Federal University of Bahia (UFBA) and a specialist in the field, contends that Contandriopoulos's focus on intervention situates evaluation strictly within the instrumental dimension of health actions. She proposes an adjustment to this framework, advocating for the replacement of the concept of intervention with that of social practices, within which health practices are understood as a particular case (Vieira-da-Silva, 2005).

As a field, Health Evaluation should define the methods for systematically collecting information on the activities, characteristics, and outcomes of services, programs, and actions. In this context, tools derived from Activity Analysis (addressed in Chapter 11), as well as other methods focused on analyzing variability – such as the Functional Resonance Analysis Method (FRAM), discussed in Chapter 12 – can be highly valuable for incorporating resilience as an attribute of the health system. This perspective becomes even more evident when Health Evaluation is viewed as an approach within evaluative research, in which procedures from social research are employed to analyze the behavior of health systems.

It is also essential to recognize that the evaluation of care quality cannot be dissociated from Health Evaluation, as it represents its fundamental objective. When standards are established to define quality care, a balance must be struck among several aspects – such as health benefits and treatment risks, monetary costs, user expectations, and individual values. This balance is influenced by four key properties:

- Access;
- Continuity;
- Coordination;

- User satisfaction.

The evaluation of resilience is, by nature, essentially formative, as resilient performance must be cultivated continuously – before, during, and after the implementation of an action or adaptation to address an event. Normative and summative evaluations are typically conducted after actions have taken place and often resemble reports on what was done, although their relevance should not be underestimated. Formative evaluations, by contrast, are generally carried out during program implementation, serving as a means to support the development of health interventions. It is also crucial that the assessment of resilience does not place excessive emphasis on immediate outcomes. Instead, the focus should be on processes and day-to-day functioning.

The structure of health systems is relatively static; their material and organizational attributes – such as the availability of facilities, equipment, and human resources – tend to remain consistent, even as their scale may change over time. In contrast, the organization of the system – that is, the set of activities and procedures used to manage this structure – is highly dynamic and varies significantly according to the context.

The quality of care also encompasses the way health workers interact with users and engage with the broader population, as well as the processes of diagnosis, treatment, and problem resolution. The outcomes of care refer to the effects of the services provided – particularly changes in the health status of individuals, as well as shifts in behavior, knowledge, and user satisfaction. By focusing on system functioning rather than solely on outcomes, the evaluation of resilient performance introduces a new dimension to the assessment of health systems.

While it is essential to establish measures for assessing the resilience of health systems, quantifying a phenomenon that depends on the interplay between system capacities and human work remains controversial. Resilience is grounded in the development of a culture within health organizations that integrates various capacities and functions, enabling and informing adaptive possibilities. Given that the analysis of a health service's resilience potential typically focuses on normal functioning – that is, how individuals handle everyday variability – it is not meaningful to assess this potential solely through indicators based on past events, especially when those events reflect system failures.

PAHO has recently adopted a strategy for the simultaneous and complementary monitoring of universal access and universal health coverage. As briefly discussed in Chapter 3, there is an important distinction between these two concepts, as well as some ambiguity in the use of the term "coverage". The monitoring of universal health coverage proposed by PAHO is based on metrics that assess the equitable availability of critical system resources – including human resources, financing, and technologies – the appropriate organization of services, and the use of intersectoral approaches to address the social determinants of health. In turn, the monitoring of universal access to health focuses on parameters that reflect equity in the use of comprehensive, adequate, timely, and high-quality health services, as well as on interventions aimed at overcoming barriers to access.

The metrics used to monitor coverage offer a broad understanding of the quality, relevance, and financial availability of health services. However, they do not, on their own, provide a complete picture of the various barriers to accessing these services, nor do they offer information on the types of interventions needed to improve access conditions. Incorporating parameters that reflect these barriers is essential for guiding the design and implementation of policies aimed at enhancing service accessibility. At the same time, monitoring efforts must also include the analysis of policies and action plans that promote changes in the organizational and financial mechanisms of the health system. This will enable national health authorities to explicitly assess progress and trends in the transformation toward universal health.

The table of indicators proposed by PAHO includes four dimensions:

- **Impacts:** provide an overview of the level of achievement of health objectives;
- **Results:** represent advances in universal access to health, considering the overcoming of barriers to access, coverage and use of health services;
- **Production:** show advances in coverage, according to the definitions of universal coverage, related to the planning, organization of critical resources, organization and care model of health services, and intersectoral actions to address the social determinants of health;
- **Strategic actions:** are organized into four main lines of action. The first focuses on integrated, people- and community-centered approaches, with an emphasis on strengthening Primary Health Care (PHC) and the organization of Health Care Networks (HCN). The second line prioritizes the political and technical capacity of health authorities to lead systemic change and to formulate legal and regulatory frameworks that advance universal health. The third line encompasses actions aimed at optimizing public financing, strengthening the care model, and ensuring universal access. Finally, the fourth line addresses the articulation

and integration of health services with various sectors of society and the productive sector – an approach aligned with the principles of the Health Economic-Industrial Complex (HEIC).

Countries adopting this monitoring framework should tailor the indicators to their specific contexts, although a comprehensive list of suggested indicators for each dimension is available in the official PAHO document (Pan American Health Organization, 2021).

Monitoring actions that focus solely on trends, without considering contextual information related to health system transformation processes, will generally fail to provide sufficient insight into the effectiveness of public policies. It is therefore essential that such monitoring be complemented by qualitative data, collected through systematic processes that enable the analysis of the nature and depth of changes introduced in the system. Indicators should be disaggregated by relevant qualitative and socioeconomic variables that reflect the implementation of key policies aimed at achieving universal access and coverage.

Ensuring the acceptability of monitoring tools is a key requirement for facilitating change processes. One of the challenges in this regard is the difficulty of adapting the full list of indicators and strategic actions to local contexts. Additionally, the aggregation of socioeconomic variables often poses a barrier to effectively monitoring equity. To address these issues, PAHO recommends selecting a set of indicators that countries can adapt to their specific needs and realities, prioritizing those most relevant to their context.

In any case, identifying resilience measures across different levels of the health system is always valuable for assessing the system's capacity to respond to crises, highlighting potential sources of vulnerability, and informing the planning of future actions. While there are established methodologies for objectively assessing the resilience potential of health systems – as will be discussed later – the challenge remains to encompass a sufficiently broad set of metrics capable of anticipating resilient performance under diverse types of disturbances.

Lagging indicator is a type of metric that relates to the past, referring to the organization's results in a given period. The dilemma of this type of indicator is that, although the probability of success increases in inverse proportion to the lag (because early interventions are more effective than late ones), the quality of the indicator increases in direct proportion to the delay in the sampling period.

The potential for resilient performance can be estimated based on historical performance during crisis events. This is particularly relevant for health systems, which – unlike many traditional systems – are marked by the frequent occurrence of extraordinary events, both at the sharp end and the blunt end of operations.

It is important to recognize that metrics are not universally appropriate for all situations. Their selection depends on the specific purpose of the evaluation, while their interpretation is influenced by multiple contextual factors – such as the degree of exposure to a disturbance or the phase of the shock cycle. Nevertheless, these assessments can serve as a valuable starting point and can motivate policymakers to develop appropriate, systematic, and routine measurement strategies. Although several tools exist for assessing the performance and safety of health systems, they generally offer limited coverage of resilience-related aspects.

What is most crucial is that indicators of health system resilience – regardless of their specific form – are proactively defined and systematically monitored, both in routine operations and during unexpected disruptive events. Establishing a monitoring and evaluation function focused on resilience as a permanent component of health information systems enhances the system's capacity to track and utilize data for evidence-based decision-making in variable contexts, supporting both rapid response and effective recovery.

Leading indicator is a type of actionable metric that impacts future performance, therefore, it is useful to support strategies and actions. It can be used as a valid precursor for changes and events that are about to happen. The main difficulty with leading indicators is that interpretation requires an articulated description of how the system works. In the absence of this, these indicators are defined by association or limited correlations. Therefore, most systems rely on lagging indicators, such as accident statistics.

Context-appropriate digital innovations can also play a significant role in enhancing the collection and use of data that reflect resilient potential. For instance, during performance monitoring or disruptions to routine services, such technologies can help transform lessons learned into timely actions and adaptations, while also strengthening capacities for preparedness and prevention in the face of future threats.

It is also essential to consider the territorial dynamics. The monitoring and analysis of each indicator, as well as the formulation of response and recovery actions, must be context-sensitive. Context should guide the development, selection, and application of measurement approaches at national, regional, and community levels, ensuring appropriate responses and strengthening equity – particularly by including and addressing the needs of vulnerable populations.

We now turn to a review of key principles that support the evaluation of resilient performance potential through multi-level metrics. These metrics capture both the emergent capacities demonstrated in the operation of health systems and the characteristics of their structural components and resources. Together, they help describe the system's resistance, robustness, state of preparedness, and adaptation strategies.

Combining approaches in assessing resilient potential

Designing and managing resilient health systems requires the identification of the factors that contribute to resilience, as well as the establishment of coherent measures for assessing these factors. However, few initiatives addressing this challenge are found in the current literature. This gap is understandable, given the functional and cognitive nature of resilience – understood as both a system goal and a capability. It is important to note that resilience, particularly in public health systems, becomes truly evident only during actual operation.

Understanding resilience requires the identification of unexpected events – which, in the context of public health, occur frequently and are shaped by high variability. There is, therefore, a clear need to identify the factors that contribute to resilience, and to develop and validate measurement instruments capable of estimating these factors systematically – while remaining flexible enough to account for their inherent complexity.

Despite its importance, resilience remains a challenging and often contested concept to measure. Scholars in the field of Resilience Engineering, for instance, are generally skeptical about the feasibility of establishing objective metrics for resilience itself. As an alternative, Hollnagel suggests that what can be measured is a system's potential for resilient performance, rather than resilience as a fixed attribute. In this sense, the literature has begun to identify key factors that are considered relevant in assessing a system's potential for resilient performance:

- **Damping capacity (or absorptive capacity):** the extent or type of variability that the system can absorb without compromising the outcome of its essential functions or components;
- **Flexibility (or adaptive capacity):** the ability of the system to restructure itself in response to changes during unwanted and/or unexpected events, whether internal or external;
- **Margin:** description of the safe operating limits of the system;
- **Tolerance:** the extent to which the system can withstand or continue to function in the presence of failures, including how it behaves as it approaches its operational limits.

Resilience Engineering focuses primarily on monitoring and managing performance at the boundaries of system competence, particularly under conditions of constant change and increasing demand. Designing for resilient performance requires careful consideration of how the key contributing factors can be measured as objectively as possible. It is important to note that both fragility and resilient performance may emerge either from necessity or from opportunity. In the case of necessity, there is a substantial body of research examining how organizations have responded when pushed to the limits of their capabilities.

Variables do not necessarily need to be quantitative; what is essential is that the connection between abstract concepts and their real-world instantiations can be empirically verified. The notions of reliability and validity are central to any discussion of measurement in science and engineering. Reliability refers to the consistency observed in repeated measurements of the same phenomenon – that is, a measuring instrument is considered reliable if it yields the same result when applied repeatedly under identical conditions. Validity, on the other hand, pertains to the extent to which an indicator accurately measures the intended abstract concept. In other words, a valid measure is one that successfully captures the phenomenon and locates its value along a defined scale.

With few exceptions, the process of developing measurement instruments is rarely documented in detail, offering limited insight into the validity and reliability of the resulting measures for researchers and practitioners. One common exception is the use of research instruments designed to capture the attitudes and psychological states of individuals involved in system operations. However, even in these cases, behavioral and emotional data remain challenging to measure directly – despite ongoing efforts to develop reliable metrics for assessing human behavior.

In the early stages of theory development for a newly recognized class of phenomena, the need for thorough discussions on instrument development is particularly critical. Without careful attention to the assumptions underlying measurement design, the emerging theory risks becoming vague – resulting in either an unnecessarily narrow or an excessively broad interpretation of the phenomenon.

Research in Resilience Engineering has been grounded primarily in field observations rather than laboratory experiments. Consequently, it has adopted a strongly interpretive approach, with a focus on case studies. The types of generalizations that can be drawn from such interpretive case studies include the development of concepts, the generation of theory, and the formulation of context-specific implications. While the principles for evaluating the reliability and validity of interpretive case studies differ from those used in conventional quantitative research, they can nonetheless be applied to assess the rigor and credibility of findings within this methodological framework.

There are several clear challenges associated with applying a quantitative approach to research in Resilience Engineering. Among them is the lack of consensus on the definition of resilience itself, as well as on the factors that contribute to it. In this context, combining interpretive and quantitative approaches appears to be a reasonable and productive strategy for advancing the development of instruments to measure resilience.

Some extreme events, although rare and uncertain, can lead to far-reaching and severe consequences. There are strong reasons to examine resilience in the context of responses to such events. Organizational performance under extreme conditions often occurs at the limits of experience, where qualified individuals and institutions are required to make high-risk decisions under significant time pressure. However, these experiential limits can be difficult to identify in advance – and sometimes even in retrospect – making the study of resilience in such contexts both challenging and essential.

Non-extreme events – typically referred to as crises – can also test the resilience of health systems by demanding a damping capacity that resides within the affected organization. The limits of a health system encompass both its internal performance capacity (e.g., the available workforce) and the boundaries that separate it from the external environment (e.g., procedures or consultations provided). All but the simplest systems possess both types of limits, requiring organizations to assess their performance across multiple – and often conflicting – dimensions. Measuring a system's margin, therefore, demands an approach that accounts for these dimensions and their evolution over time. Given the nature of extreme events and their potential to disrupt system functioning, this multidimensionality poses a significant challenge for evaluation.

Similar to margin, tolerance refers to the boundary conditions within which a system can continue to function despite some level of malfunction. However, while margin relates to system performance, tolerance focuses on how that performance is achieved – specifically, how people, technologies, and processes operate under stress or partial failure. In measuring margin, one of the primary challenges is data scarcity. In contrast, measuring tolerance requires the development of process-level descriptions of organizational behavior, such as identifying redundancies that allow continued operation despite component failures. This often involves comparing system functioning before and after events, and examining decision-making processes at both individual and collective levels.

The literature on organized disaster response highlights the importance of planning for organizational capacity to manage extreme events, while also emphasizing that flexibility and improvisation remain critical for mitigating losses during the response phase.

Nevertheless, the measurement of flexibility and adaptation has traditionally focused on product-oriented constructs, such as the perceived effectiveness and creativity of the response. Only recently have efforts emerged to develop process-oriented measures of flexibility and adaptation, though these remain limited in scope.

Margin and tolerance are particularly challenging to evaluate, as estimating these factors requires identifying system limits – limits that are heavily influenced by system design and the interplay of multiple variables.

Every approach to evaluating resilience faces two primary threats to its effectiveness. First, post-disaster reports are notoriously unreliable, particularly when those involved in the event are still under significant stress. Achieving consistency often requires interpreting observations from mentally and emotionally exhausted participants. Second, external validity is inherently limited – except in a few rare cases. To enhance external validity, it is necessary to measure the phenomena associated with resilience at a more granular level and subsequently aggregate the results to capture broader patterns.

Pre-disaster assessments present significant challenges, as they often rely on relative measures of performance or efficiency. In such cases, estimates are typically based on expert judgment rather than historical data. Given the practical difficulties in developing robust measures for assessing resilience in response to extreme events, it is reasonable to pursue understanding through mixed-methods approaches. These approaches allow for the integration of quantitative and qualitative methods, enabling a more comprehensive evaluation of outcomes through the application of theoretical principles in field studies.

There remain significant opportunities for the development of technologies that support the measurement of resilience in relation to organizational boundaries. At the same time, improved approaches are needed to capture data on both blunt-end and sharp-end phenomena, enabling more comprehensive analyses of resilience across all levels of the system.

Summary

In previous chapters, we established that resilience is a fundamental attribute of universal health systems. This leads to the central question addressed in this chapter: how can resilience in public health be monitored and evaluated using management indicators that are contextually appropriate and operationally relevant?

There are some points of convergence among the various definitions of resilience – such as its association with adaptation in crisis situations, monitoring, and evaluation. Nevertheless, the development of indicators that enable managers to strengthen resilience remains an unresolved challenge.

Some argue that resilience can be measured retrospectively, based on outcomes already achieved by the system. This perspective is supported by the World Health Organization (WHO), which has used it as the foundation for a set of conceptual frameworks and studies on resilience to disruptive events – an approach that has been further developed by international organizations engaged in disaster management.

At the other end of the spectrum, some scholars view resilience as intrinsically linked to the system's day-to-day functioning and dependent on the skills and capacities that workers develop through their routine activities, based on the resources available to them. From this perspective, resilience is not seen as an outcome already achieved, but as a potential that both systems and individuals possess and can cultivate. In practice, there is no conflict between these two approaches. They can be applied complementarily, as long as the management objectives for resilience align with the chosen measurement approach or set of indicators.

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Chapter 9

Postulates for a Tentative Epistemology

Epistemology – the philosophical study of knowledge – is essential for understanding how we acquire, validate, and apply knowledge across disciplines. It distinguishes between mere opinion and justified truth, fostering intellectual rigor in science.

Epistemology enables the structuring of a theoretical framework and corresponding practices for a given concept, allowing its study from multiple and diverse angles. Bridging the existing epistemic gap in health systems resilience research is essential to delineate the boundaries between scientific truth – defined by the critical evaluation of principles, hypotheses, and knowledge validity – and mere belief. Establishing an epistemology that distinguishes common sense from science will clarify concepts and support addressing the logical, semantic, and ontological challenges related to resilience in public health.

Science operates cooperatively, bringing together a community of researchers with diverse viewpoints, and the field of public health integrates diverse bodies of knowledge, fostering collaboration among various epistemic communities. But what would be the initial postulates for an epistemology for resilience in the field of public health? A tentative epistemology should be grounded in a set of premises drawn from multiple empirical studies that constitute a knowledge base. Thus, we start with a few axioms based on recent experiences and literature.

> *An axiom is a statement or proposition that is accepted as self-evident or as an initial consensus, not requiring proof or demonstration, foundational for building or accepting a theory. According to empiricists, axioms are constructed from generalizations of empirical observation. In the applied social sciences, especially where there is not yet a dominant paradigm (Kuhn, 1997) , the establishment and, especially, the validity of axioms can be made, albeit in a preliminary way, based on studies that present similar results and corroborate the premises. Thus, axioms can be accepted as regulators of postulates, serving as a starting point to support demonstrations of empirical truths, elaboration of objectives, methods, and practices arising from a theory.*

First Axiom: demand fluctuations require the dynamic combination of structure and functioning

Recognizing resilience as an attribute of health systems does not exempt us from considering the circumstances in which systems operate and that enable (or constrain) the emergence of these characteristics.

Embedded within the socioeconomic context of their countries, universal health systems are inevitably self-organizing and adaptive. To understand these systems, it is essential to examine the skills and capacities they deploy to absorb, react, adapt, or transform in response to different types of events – guided by both implicit and explicit rules and shaped by the diverse decisions and interactions of various actors, including patients, trained professionals, managers, politicians, and the private sector.

Reconciling stability in the functioning of essential public health functions (EPHF) with a configuration of its building blocks that aligns with the operational context and supports adaptation would position health systems to achieve high institutional capacity and resilient behavior. This, in turn, it would positively impact management systems, enhance care pathways, improve the quality of care, and ultimately contribute to better health outcomes.

Resilience in public health must encompass both structures and functioning. It is not feasible to conceive of – or evaluate – resilience to major events based solely on structures. Therefore, the challenge lies in managing the functioning of EPHFs in ways that enable decision-makers to make informed choices, ensuring the system operates optimally both in routine conditions and during major crises.

Second Axiom: resilience is about handling both small and large events

This premise stems from a recurring question: Is the resilience required to manage major changes or disruptive events – such as pandemics, natural disasters, or major accidents – the same as the resilience needed to address smaller disruptions like increased demand, surges, shifts in political arrangements, or technological changes?

It is important to remember that resilience does not require the occurrence of an acute event. On the contrary, particularly in public health, numerous events of varying intensity occur daily. The resilience of health systems depends on developing attributes that keep them continuously prepared for events of any nature or magnitude, especially given the inherently unstable context of delivering public health services.

These attributes are activated as needed, both during routine delivery and in exceptional emergency management scenarios. Maintaining stability and enhancing shock-absorption capacity are central themes in Disaster Management, making its concepts foundational when defining resilience across other fields. However, developing resilient behavior also requires mobilizing efforts to anticipate future failures amid increasing complexity driven by variability. Crucially, people working in universal health system must be able to discover novel ways of operating in novel situations.

As situational awareness evolves, decisions regarding courses of action must adapt accordingly, enabling the mobilization of critical resources to support responsiveness. In the context of public health, this communication extends to the capacity for collaboration between the system and other civil society players, since community engagement enhances the capabilities that contribute to resilient performance.

Risks to people extend beyond outbreaks of infectious or contagious diseases. While some events are sudden and rare, others develop gradually over long periods – such as droughts in Brazil's Northeast or flooding in the South and Southeast. Small-scale events with limited consequences occur regularly, whereas others may escalate into emergencies or catastrophes with profound impacts on public health, well-being, and long-term health outcomes.

Third Axiom: public health functions are influenced by endogenous and exogenous variables

A question seldom addressed in the literature on resilience in various kinds of complex systems is whether the processes for managing external events are the same as those required to handle internal variables. However, in several disciplines – particularly Systems Theory – resilience is understood as a process or set of processes that respond to both internal and external threats, variables, or situations, rather than as a static or structural property of a system (Ungar, 2018).

Several processes are activated in adverse contexts, for example: (a) persistence; (b) resistance; (c) recovery; (d) adaptation; and (e) transformation.

Persistence enables a system to keep stable functioning – both internally and externally – even when stressors try to alter it. Although system stability may give the appearance of idleness, persistence often demands significant effort and resources.

While persistence describes a system that continues its usual functioning by drawing on necessary support to withstand stress and avoid threats, resistance refers to a process in which the system mobilizes resources to prevent the emergence of new behaviors, facing the risk of overload.

The recovery process is conceptually problematic for health systems, as it implies a return to the same level of functioning the system was before the shock - a state that may not be appropriate. In addition, returning to a previous state is unlikely if new information and functionality has been introduced to help the system cope with the disturbance.

Transformation occurs when a system undergoes a radical change into something new. Like adaptation, transformation describes the need for or result of change but does not specify when or whether that change is desirable.

Fourth Axiom: resilient performance must be deliberately designed

Systems that rely solely on individual resilience are often overloaded. The "informal resilience" that arises from unmonitored adaptations may cause systems destabilize, spiraling out of control.

The WHO highlights a set of skills centered on the functioning of essential public health functions (EPHF) and the broader determinants of health, equity, and health promotion, framing these as key elements of resilience. These characteristics – awareness, mobilization, diversity, self-regulation, integration, adaptability, and transformation – form a conceptual framework emphasizing the importance of systemic-level design that supports people's adaptive capacities (World Health Organization, 2021).

With some overlap, the World Bank identifies resilient skills for health systems, which include awareness of threats; agility in responding to demands; shock absorption; adaptability to minimize interruptions; and the ability to transform after a crisis by applying lessons learned (World Bank, 2022). This framework underscores the importance of multisectoral collaboration – engaging government and society – and linking preparedness with service delivery, political actions, and investments in public health.

The initiatives align with the idea that resilience in public health cannot depend on improvised responses or individual efforts alone. It must be deliberately built into the design and functioning of health systems, ensuring that adaptive capacities are supported, coordinated, and sustained over time. Without intentional planning and investment, informal adaptations risk leading to instability in EPHFs.

How do we know resilience is there if we can't see it?

For centuries, physicists and astronomers have relied on visual observations – based on electromagnetic interactions – to map the cosmos. If something does not interact electromagnetically, it remains invisible, and anything unobserved was often assumed not to exist. Today, however, it is widely accepted that about 85% of all matter in the universe is invisible. Although the true nature of this dark matter remains unknown, there is overwhelming indirect evidence of its existence. One key piece of evidence is the way dark matter's gravitational interaction with ordinary visible matter curves space-time – an effect crucial for upholding current physical principles. Thus, while dark matter cannot be directly observed, its presence is inferred through its impact on the cosmos.

These same principles apply to resilience in public health. By observing how health organizations respond to events of varying magnitudes – whether during routine operations or major public health crises – we gather indirect evidence of their resilient capacity, even though consensus is lacking on how to operationalize, prioritize, or directly measure resilience within health management processes, as we have seen in previous chapters.

How do we know something exists if we cannot see it? Adaptations constantly occur within sociotechnical systems, yet we often only become aware of whether the useful properties to handle an event were present and activated when something goes wrong – such as an accident. Visual observations of work activities, as practiced in human factors, depend on external evaluation and interactions with workers, capturing only a limited snapshot of the system's overall functional dynamics. If an element remains unseen, it stays invisible to management.

This is a factor that may explain why resilience has not been explicitly developed as an attribute in the management models of complex systems like public health. Today, many scientists and organizations recognize the importance of resilience for health systems strengthening, yet there is no consensus on its precise definition or how it should be operationalized and managed – whether in policymaking or service implementation (Jatobá, 2025). Despite this, there is strong indirect evidence of resilient practices in action. However, how organizations facilitate, support, or sometimes hinder these practices is difficult to observe directly, even though their impact on system stability and behavior is clear.

In science, what we can measure—and how accurately—depends on the system itself: some properties are clear, while others become distorted when observed. This mirrors public health challenges, where collecting data (like self-reported behaviors or long-term policy impacts) can unintentionally alter the very things we are trying to study. While perfect measurement may be impossible, the lesson is not to abandon rigor—it is to design policies that account for uncertainty, prioritize adaptable strategies, and use evidence pragmatically even when it is not flawless (Oppenheimer, 1954).

Variability, resonance, and volatility in the outcomes of EPHFs

In particle accelerators used for quantum physics research, powerful magnets guide particles along precise trajectories. However, imperfections in these magnets can induce resonances that disrupt particle movement, creating complex magnetic structures. Addressing and analyzing these challenges demands adaptive capacities, despite current paradigms identifying well-known determinants within these controlled research environments.

Similarly, the functioning of universal health systems relies on structural dimensions that steer its EPHFs toward ensuring people's access to services at adequate levels of quality and resolution. However, disturbances in these structures inevitably alter the outputs of these functions, with the resulting volatility resonating throughout the system's overall operation.

Existing literature includes methods dedicated to analyzing the resonance between system functions caused by volatility in their outputs. The most established of these is the Functional Resonance Analysis Method (FRAM), which we will explore in Chapter 12.

Although the minimum inventory of EPHFs proposed by the WHO aims to support population well-being, the effective operation of these functions depends on how a health system configures its institutional capacity within manageable margins. This becomes evident when systems face changes in governance or struggle to mobilize essential funding, workforce, or technologies to maintain basic functionality. Such variabilities – whether political or technical – can cause resonances among system functions, impacting the accuracy and timing of their outcomes.

If a resilient health system is one that adapts to minimize variability in its outputs – thereby maintaining reasonable levels of problem-solving capacity and quality – then assessing its maturity for resilience can also be approached by evaluating the volatility of the determinants of its behavior.

This idea allows for a direct connection between models that represent variability in systems' functions – such as FRAM – and an objective assessment of resilience, since system design fundamentally aims for stability in outcomes. While variability in EPHFs arises from adaptations to dynamic contexts, a resilient system maintains stability in its outputs – that is, it consistently produces reliable, stable care.

Evaluating the evolution of structural indicators and their volatility over time reveals variability in their aggregation, indicating either an approach toward or a distancing from structural rupture within the system. Conversely, variability in functions tends to create a mismatch between system capabilities and demands, becoming a bottleneck for implementing solutions in dynamic contexts.

Addressing Volatility in EPHFs: Toward a Variability-Based Theory

Based on the postulates and axioms outlined, a possible theory of resilience in public health is that it involves designing, implementing, and maintaining national systems capable of ensuring the uninterrupted, problem-solving, and high-quality operation of EPHFs during sudden fluctuations in external or internal demand. These systems must adapt to the inherent variability in policy implementation while adhering to the principles of universality, comprehensiveness, and equity in programs and services.

> *Service levels are based on the combination of different capacities and skills, employed at different levels. The service levels vary over time, depending on the system's attributes. They depend on the combination of various capacities and skills deployed across different layers of a health system.*

This figure illustrates how resilience in public health systems can be represented by a curve (α) showing the relationship between service levels (S) and time (t). The shape of the curve reflects the variability (Δv) in Essential Public Health Function (EPHF) outputs:

- Positive variability (e.g., adaptive capacity, improved responses) increases the curve's upward concavity, indicating stronger resilience over time;
- Negative variability (e.g., disruptions, resource shortages) flattens or inverts the curve (convexity), signaling volatility or declining resilience.

The curve approaches a positive asymptote (ideal steady state), demonstrating how systems can stabilize despite fluctuations. In short: variability in EPHFs directly shapes resilience outcomes—whether reinforcing or undermining them.

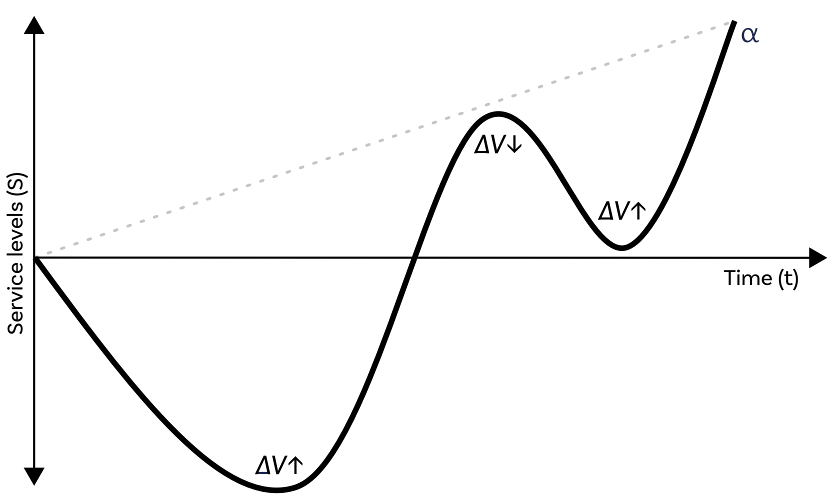

Figure 2: How variability (Δv) drives volatility in the outcomes of EPHFs: Positive Δv boosts capacity and, therefore resilient performance; negative Δv increases fragility.
Source: The authors.

The curvature of curve α increases proportionally with variability (ν). Therefore, at low service levels, positive variability should be encouraged to enhance the convexity of α. Conversely, at high service levels, variability should be maintained within stable limits over time.

Like we've been discussing throughout this book, eliminating variability is unrealistic due to the influence of multiple factors on system functioning. However, managing variability at appropriate service levels is crucial to operationalize a resilient system – one capable of sustaining routine essential public health functions at adequate service levels while adapting to demand fluctuations, whether routine or arising from major public health events.

Summary

The resilience of public and universal health systems depends on their ability to dynamically adapt to disruptions – ranging from routine stressors like seasonal disease surges to acute crises such as pandemics or conflicts – while sustaining core functions. Unlike industrial systems, health systems cannot pause operations during emergencies; they must balance stability with flexibility.

A proposed theory conceptualizes resilience as a balance between service-level stability (minimizing output volatility in essential public health functions) and adaptive capacity. This is visualized as a curve correlating service levels with time, where low volatility indicates resilient performance even amid challenges. Resilient systems maintain adequate service levels despite variability, avoiding collapse but not necessarily achieving optimal outcomes.

Policy implications prioritize prevention over crisis containment, leveraging community strengths to drive change. Systemic analysis addresses root vulnerabilities (e.g., funding instability) while enhancing protective mechanisms (e.g., workforce training). Resilience remains intangible, akin to dark matter – observed indirectly through effects like service continuity during crises. Operationalizing resilience demands iterative learning, cross-sector collaboration, and adaptive design to navigate evolving threats. For example, predictive models using AI or statistical tools can forecast volatility, guiding interventions.

Ultimately, resilience in public health is contextual, shaped by historical and institutional pathways. It requires ongoing efforts to strengthen governance, partnerships, and equitable service delivery, ensuring systems withstand disruptions while advancing long-term population health. By focusing on both vulnerabilities and strengths, policies can transform resilience from an abstract concept into actionable strategies, fostering sustainable, equitable outcomes in an unpredictable world.

With this, we have concluded the first part of our journey, which introduced the key concepts underlying the integration of resilience into the field of public health. The second part presents various methods, techniques, and tools for analyzing, evaluating, measuring, and operationalizing resilience, illustrated with examples of recent practical applications.

Part

Methods, Techniques, Tools and Applications

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Chapter 10

Preamble

Understanding the regular functioning of a system – not in the sense of norms, but in terms of its usual operations – is the foundation for fostering positive transformations in resilience.

As we have seen throughout the first part of this book, the resilience of health systems remains an evolving concept, where several paradigms, with varying degrees of structure, coexist while competing for recognition and consolidation. Resilience Engineering – which focuses on how the system operates, or what the system does – has its roots in a review of the Safety Engineering paradigm. It is a well-structured field with extensive international literature and established methodologies. Therefore, the dissemination of precepts, concepts and especially methods coming from Resilience Engineering can improve resilience in health systems.

Other approaches applied in public health systems, though more dispersed, share a common emphasis on assessing resilience through the structural analysis of health systems – essentially, evaluating what the health system possesses. This concept is adopted by WHO and associated organizations, such as PAHO and the European Observatory on Health Systems, linked to the European Union.

It is still too soon to determine whether the evolution of these two major strands will converge into a dominant paradigm. However, both views agree that resilience lies in the ability of health systems to fully mobilize and adapt to the unexpected. In today's complex world, this capability is indispensable for any health system, regardless of its conception.

A health system's capacity to manage unexpected events is most evident at the sharp-end, where direct interactions between health workers and patients drive adaptation. However, especially in major crises, like the COVID-19 pandemic – but not limited to them – adaptations can also occur at organizational and political levels. Public health systems are emblematic in this sense, given the importance of the patient's role in ensuring comprehensive delivery of care (e.g. accepting vaccination during epidemics).

The fundamental distinction between different resilience concepts lies in their emphasis on specific tools used within the health systems. While Resilience Engineering focuses on the sharp end – addressing aspects of healthcare and the interactions between patients and workers – recent public health frameworks tend to concentrate on the blunt-end, examining the organizational structures that support system operations.

Much of the Resilience Engineering's methodology stems from Ergonomics and Human Factors, given this field's close relationship with work-related scientific domains. Ergonomics is a discipline dedicated to studying how people interact with technology, organization and environments, focusing on interventions that aim to improve safety, comfort, well-being and efficiency of human activities (Brazilian Ergonomics Association, 2004).

This definition aligns with that of Alain Wisner, who states: "Ergonomics is a set of scientific knowledge related to man necessary to engineer tools, machines and devices that can be used with the maximum comfort, safety and effectiveness" (Wisner, 1987, p. 598). Work activities involve interconnections between various elements, including tasks performed using artifacts (devices, instruments, and signals), procedures (protocols, routines, and methods), and regulations, whether formal laws or practical organizational norms.

Cognitive Ergonomics specifically focuses on aligning human abilities and limitations with machines, tasks, and environments. It also examines the use of certain cognitive abilities that allow us to operate complex systems such as learning, reasoning, and decision-making. This field studies the mental or cognitive models workers construct while performing their tasks, which shape their operational reasoning. The way an individual perceives and processes information affects how they carry out their functions. Therefore, to capture the essential aspects of work – including the context in which it is carried out – it is necessary to analyze both the activities and the cognitive processes of workers.

Practice and experience, as key determinants of cognitive development, enable and strengthen various elements of health work. Enhancing situated cognition fosters experienced workers and refined practices, which help clarify roles, strengthen relationships, and improve planning processes. Real-world work situations develop cognitive skills and strategies to enhance resilient performance.

These roles, responsibilities, and relationships can be pre-defined in a variety of ways, including the planning process, operational procedures, training, and simulated exercises. Assessing knowledge about work activities helps us determine whether a health organization or service has the potential for resilience, with the cognitive skills required to respond resiliently to threats.

To integrate practice and experience with learning and anticipation, organizations must ensure that all relevant details are systematically gathered and analyzed. Developing resilient-oriented practices is closely linked to how the system is designed and operated. We can take as an example securing adequate funding for strategic actions or implementing training programs for workers.

From the perspective of complex systems, resilience-focused management should leverage practice and experience to enhance resilient capacity. Workers must have the necessary skills and support to adjust their activities and decisions as situational awareness evolves, thus operationalizing the system's adaptability.

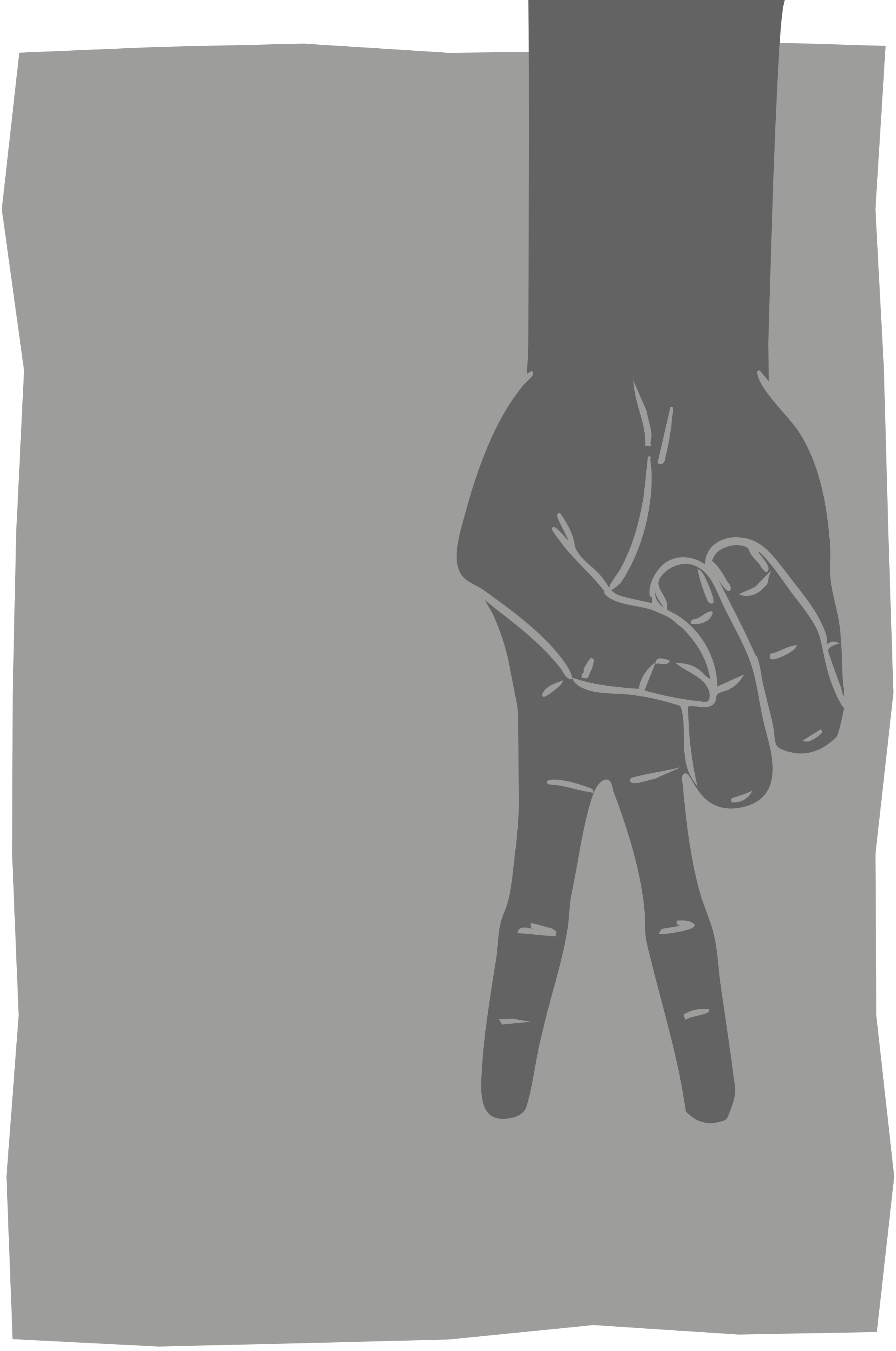
To characterize complexity, which is multidimensional, ergonomists employ various methods. However, when used individually, these methods fail to provide a comprehensive analysis of complexity. Walker *et al.* (2010) reflect on this challenge, proposing two ways to view complexity: (i) as a quantitative measure, suggesting that some systems are more complex than others; and (ii) as an emergent phenomenon resulting from unexpected interactions.

Although this multiplicity of perspectives may seem paradoxical, it significantly enriches our understanding of how sociotechnical systems can be designed for resilience. Under these different perspectives, structure and dynamics self-organize, allowing systems to adapt to internal and external disturbances while maintaining the system under control. It is important to note that these adaptations are generally not deliberate or explicitly mandated. Instead, in sociotechnical systems, adaptation emerges through a quasi-organic process of redistribution of activities and responsibilities to manage variability.

In evolving theories of complexity, order and disorder are inherently linked, and system development is largely shaped by this conflict. Efforts to impose order are never entirely achieved, even in seemingly stable systems. In other words, order or stability in system outcomes result from a continuous effort to manage variability. Whether sociotechnical systems are becoming increasingly complex, due to constant technological advances and increases in scale and internal and external interactions, remains debatable. What is certain, however, is that the speed of change and the challenges of system operation are increasing.

To address this, we need methods and approaches that assess interaction strengths within a system and understand how dynamic patterns of interconnection shape its functions. Additionally, new methodologies must illustrate how sociotechnical systems evolve in different levels of complexity and define their boundary conditions, inclusion/exclusion criteria of specific elements and degree of interconnection. In public health, reaching a clearer consensus on what constitutes a system is essential. Without this clarity, classifying health systems as complex risks being imprecise – or misleading.

In the next chapter, we will explore public health work analysis and methodologies that provide critical insight into resilience.



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Chapter 11

Public Health Work Analysis

For resilience, the key factor is not merely how protocols are followed, but how people behave within them.

Organizations are often imagined as linear systems with little or no variability. Understanding how they function would involve breaking them down into smaller parts and analyzing each element separately – a logical and seemingly simpler approach.

While this approach can be effective in relatively stable systems, it does not fully capture the complexities of more dynamic environments. Decomposing a system may overlook crucial interactions between its components. In highly intricate systems like public health, fully describing the behavior of a service or program is nearly impossible, as it must account for numerous possibilities and uncertainties.

Furthermore, in complex systems, outcomes are greater than the sum of their parts. Their elements can interact in multiple ways, responding dynamically to variabilities. Because of this, their behavior is often nonlinear and unpredictable over time. The relationships within such systems are also nonlinear and highly sensitive to change.

Workers in complex sociotechnical systems navigate variable contexts using tacit rules based on instinct, experience, and mental models. For instance, health workers explore patients' complaints, concerns, and expectations beyond their symptoms. In the health sector, workers, providers, patients and other stakeholders have expectations that go beyond assistance. There are conflicting interests between stakeholders and health workers, as well as differing views on quality of care. Even when all players act in good faith, external factors such as costs and political instability influence assistance levels and quality.

To grasp how a complex system operates and how its resilience manifests, one must observe it in action, particularly during adverse events. However, frequent, low-harm occurrences often become normalized, making them difficult to identify and describe despite their significant impact on system behavior.

Designing products and services is not inherently difficult for most organizations. However, in healthcare, controlling population preferences, expectations, and territorial contexts is impossible. Because complex systems self-regulate, imposing a single organizational model is unfeasible. Consequently, not all actors involved in healthcare can effectively manage systemic complexity. Instead, the focus should be on how they navigate this complexity, maintain stability, and enhance system performance through the development of resilient abilities.

Activity theory

Activity Theory, originating from Russian psychologists Lev Vygotsky and Aleksey Leontiev, explores how the introduction of tools and processes influences human work (Leontiev, 1978; Vygotsky, 1978). This theory gained prominence in the 1980s, particularly in Human-Computer Interaction (HCI) studies. Over the last decades, its scope has expanded beyond the field of human and social sciences, becoming a multidisciplinary approach increasingly used in the study of interactions between people and technology in evolving work environments.

In this sense, it is particularly useful in situations with a significant historical and cultural context and where participants, their purposes and tools are rapidly and constantly changing.

A key concept in Activity Theory is the discrepancy between prescriptions (Work-As-Imagined, WAI) and actual work (Work-As-Done, WAD). Workers constantly adapt to disruptions, which often signal systemic contradictions and opportunities for change. Understanding these contradictions is crucial for assessing the potential for resilience or brittleness. In other words, even though they are conflicting, the object and reason for these contradictions give coherence and continuity to actions, keeping the system stable and at the same time at the edge of instability. Identifying such contradictions enables professionals to align WAI and WAD, ensuring system functionality and stability. This analysis is essential for developing a shared vision to mitigate disruptions, fostering adaptive capacity and resilience rather than fragility.

Yrjö Engeström, in his development of Historical-Cultural Activity Theory, emphasizes that studying socioeconomic structures separately from individual behavior presents a misleadingly static view of work environments. He argues for a dialectical approach that connects social structures with individual actions, recognizing humans as active agents who learn and evolve (Engeström, 1999). As social transformations demonstrate, human activity is diverse and dynamic. Therefore, any theory seeking to understand activity must account for this complexity.

Activity Theory evolved from the historical-cultural school of psychology. A fundamental principle of Activity Theory is historicity, though its implications are often underexplored. According to Engeström (1999), this may be because any conceptual framework that posits a predetermined sequence of stages of socio-historical development can easily suggest problematic notions of what is “primitive” and what is "advanced", thereby drastically reducing sociocultural diversity and underestimating its significance in people's work.

Another reason may be the poor development of models for system structures, as historical analyses are often based on small-scale abstractions. Thus, if the unit of analysis is too small, such as an individual or a specific situation, the narrative is reduced to a kind of "biography". Conversely, if the unit of analysis is society as a whole, the complexity increases substantially. By considering the system as the unit of analysis, it becomes possible to achieve a manageable scope.

Engeström sees joint rather than individual practice as the unit of analysis for Activity Theory. With a focus on social transformation, he considers the structure of society an essential element in any analysis, including the conflicts within social practices. According to him, perturbations or constraints – those "contradictions" between WAI and WAD – serve as the "driving force of change and development", with transitions and reorganizations within and between activity systems being intrinsic to evolution. It is not only the subject but also the environment that is modified through activity.

This perspective on work strongly influences Resilience Engineering. Prominent authors such as Hollnagel and Woods (2005) reinforce the importance of collective work and human cognition in managing disorder.

Cognitive engineering

Any attempt to discover how context variables affect human performance is informative, since the mental processes of workers is always influenced by the situation in which they carry out their activities (organizational culture, work environment, etc.), and by their cognition (level of knowledge, reasoning and decision-making, attention, etc.).

Therefore, all these aspects need to be considered in system design to make work both easier and safer. Making work easier involves designing and developing enablers or creating ways for workers to better understand their work. Making work safer means preventing operational failures, ensuring operators perform tasks correctly, and providing mechanisms for immediate error detection.

These considerations led Professors Hollnagel and Woods to develop the foundations of a new discipline for system design based on human activity, which they called Cognitive Engineering. In this new conception, the human element must be integrated into the entire design of a work system. They begin their book *Joint Cognitive Systems: foundations of cognitive systems engineering* by listing what they called "the driving forces" – factors that gave rise to the need for a complex sociotechnical systems engineering approach based on cognitive aspects of work (Hollnagel; Woods, 2005). These aspects are as follows:

- The growing complexity of sociotechnical systems: with the continuous expansion of digitalization (or information technology), computers have become the dominant means for work, communication and interaction, reshaping work performance and creating new fields of activity;
- Problems and failures arising from the clumsy use of emerging technologies: rapid changes in work performance have worsened conditions for professionals, leaving them with insufficient time to adapt to increasing complexity;
- Limitations of linear models: the Engineering and Computer Science communities have subtly adopted the notion that humans are information-processing systems, leading to a fragmented understanding of human-machine interaction.

Also, according to Hollnagel and Woods, it is essential to distinguish between technological systems – where technology plays a central role in determining outcomes – and organizations, where this role is assigned to people. These authors propose an approach to cognitive systems engineering that considers organizations as artifacts of a social nature, designed for a specific purpose, in which certain activities must necessarily be performed by people, while specific tasks are assigned to machines.

Cognitive Engineering has increased the need for methods and techniques to understand cognition at work. Professors Beth Crandall, Gary Klein and Robert Hoffman, in their book *Working Minds: A Practitioner's Guide to Cognitive Task Analysis*, propose a set of methods to study reasoning in the execution of work within complex systems. This approach, called Cognitive Task Analysis (CTA), supports the systematic identification of fundamental cognitive issues in people's work, contributing to the development of tools, technologies, and work processes (Crandall; Klein; Hoffman, 2006), and is based on three main aspects:

- Knowledge capture: comprises a set of methods used to obtain information about what people know and how they know it;
- Data analysis: consists of structuring collected information, identifying findings, and discovering their meaning;
- Knowledge representations: encompasses the tasks of displaying data and communicating meanings and discoveries.

Twenty years earlier, engineer Jens Rasmussen (1926-2018) had already stated that every system, regardless of its level of automation, depends on human intervention to some extent. While a system may operate without human interaction under normal conditions, its existence still relies on a human team to maintain the necessary conditions for satisfactory performance, especially when unforeseen events are likely to happen (Rasmussen, 1986). Rasmussen suggests that in highly automated sociotechnical systems, humans act based on goals, and managers tend to model human activity by focusing on the gap between what is intended and what is actually achieved (similar to the gap between WAI and WAD). According to the author, in familiar environments, human activity is not primarily guided by norms or procedures but rather by immediate goals, controlled by rules learned through practice and proven effective. In unfamiliar or more complex situations, behavior may be guided by written rules, such as operational procedures, to help workers achieve their objectives.

The taxonomy of human activity models proposed by Rasmussen appears in Kim Vicente's work as a framework called Cognitive Work Analysis (CWA) (Vicente, 1999). Although similar in origin and principles, CWA should not be confused with Cognitive Task Analysis (CTA) proposed by Crandall, Klein and Hoffman. While CTA focused on understanding the mental process behind decision making, Vicente's approach provides a structured framework for modeling workplace behavior, incorporating domain models, control tasks, strategies, socio-environmental factors, and worker competencies, thereby offering a more formalized approach to system modeling.

Vicente's CWA is ecological, as it focuses on analyzing the constraints imposed by the environment or context of an activity. It enables managers and designers to develop organizational processes and technologies that align with these constraints, allowing workers to build a mental model of their environment that accurately represents real-world conditions. These models, applied across five levels of information – functional purpose, abstract function, generalized function, physical function, and physical form –, provide designers with deeper insights into how workers' cognition can be incorporated into system design. With its ecological orientation, CWA focuses on both the work environment and worker cognition. By describing relevant constraints, it supports the development of more appropriate and effective technologies for assisting workers.

Ergonomic Workplace Analysis (EWA)

Older methods of analyzing work at the sharp end of systems were limited to collecting data about workers' tools, machines, and support devices. This approach, known as Analysis of Times and Movements, derived from the Taylorist paradigm of production engineering, and was strongly challenged by Ergonomics, which offer a deeper analysis of work activity. For ergonomists, the Analysis of Times and Movements must include contextual factors, such as local characteristics, environmental risks, social organization of activities, standards, errors, procedures, requirements. It also depends on techniques capable of exploring work situations more broadly, considering both organizational and physical aspects of the work environment, as well as worker cognitive aspects. Ergonomics, therefore, stands out as a science dedicated to transforming work situations.

One of Alain Wisner's main contributions in this regard is the Ergonomic Work Analysis (EWA), an approach aimed at solving problems related to the mismatch between work and human characteristics. Most of these problems arise from production systems that are inadequately designed or adapted, focusing solely on financial or technical aspects while disregarding human functioning and variability.

The purpose of EWA is to ensure that workers' day-to-day activities unfold favorably within their own context. Therefore, its analysis is based on real work observations, incorporating numerous individual and social aspects, such as conflicts, misunderstandings, and negotiation processes. This method of collecting empirical data allows for interaction between the observer and workers, leading to new, specific, and situated questions about procedures, automation system design, workplace layout, safety, and more.

By emphasizing the essential role of the work context rather than just the physical movements of workers operating machines, EWA emerged in opposition to traditional work analysis methods from Systems Engineering, which were previously limited to the study of time and movement. Thus, the context and cognitive aspects of work become an essential part of worker behavior analysis, as the distinctions between observed behavior and how the operator perceives their activities are key elements of the analysis.

To obtain objective data, ergonomists study workers' activities within their context. As a result, the adjustments workers make to accommodate variability in work situations become the primary observable aspect and the most critical element for understanding how people work, which is also an essential factor in resilience analysis.

There are many approaches to EWA, all revolving around the same principles. Wisner's original proposal – which has already been adapted by several authors, including professor Mario Vidal – is structured into five basic stages:

- **Framing:** provides the foundation for environmental and activity analysis by capturing how workers express their needs for transforming work situations. At this stage, the ergonomist collects workers' opinions;
- **Environmental analysis:** the first observational phase, which also includes documentary analysis, highlighting key aspects such as financial, technical, organizational and social factors. This phase defines the limits of ergonomic action and establishes the work situations to be prioritized;

- **Activity analysis:** the core of the analysis conducted among workers in identified work situations. Observations from this phase describe how work is actually carried out and provide insights for transforming these situations;
- **Operation modeling:** develop a project based on the ergonomists' intervention planning to improve work situations;
- **Validation (or restitution):** consists of negotiation between ergonomists and workers to determine how the intervention will be implemented. The parties involved – ergonomists, workers, employers – review the intervention project and define the necessary actions for execution.

Mario Vidal (1994) proposes an evolution of Wisner's EWA in which Environment Analysis and Activity Analysis merge into a single phase entitled Global Analysis. At this stage, work situations are described to identify those that truly require intervention. To achieve this, the functional context of the organization must be described covering aspects such as its population, work organization, processes, and scope of action. This process results in a preliminary diagnosis of work-related problems, defining the focus of the analysis.

The starting point of EWA is the relationship between managerial demand and the set of workers' complaints. The initial findings based on testimonies of managers and workers about possible causes of workplace issues must be supplemented with on-site observations. However, the results from later phases of EWA may lead the ergonomist back to the starting point, challenging managerial demands and/or workers' complaints and requiring a reassessment of the situations This cyclical process causes the analysis to unfold through multiple iterative loops.

This iterative approach, centered on analyzing work activity and actively listening to workers, is fundamental for Vidal. For him, the workers' general perceptions of the problems affecting work situations play a decisive role in the acceptance of the proposed solutions. As subsequent EWA phases involve rounds of confirmation, active listening to workers remains the primary focus of analysis. To improve the flow and capture of information throughout the various phases of an EWA, Vidal suggests forming three groups, comprising ergonomists, researchers, professionals, and managers of the studied organization, from the initial ergonomic request to the validation of results:

- **Stakeholders:** professionals within the organization responsible for supporting fieldwork in EWA. This group consists of leaders associate with the initial demand and have the necessary credentials to grant ergonomists access to various levels of the organization;
- **Group of interest:** this group comprises the subjects of the analysis and is responsible for identifying which work situations will be analyzed and criteria for selection (e.g., the most critical, more time-consuming, or cognitively demanding tasks);
- **Follow-up group:** professionals within the organization who will collaborate with the ergonomists as part of the analysis team. They may be recommended by the support group, but must have close ties with the focus group, as they provide key insights into how workers perform their tasks. They facilitate observations, connect ergonomists with professionals on-site, organize meetings, validate results, etc.

Human interaction with a physical system always consists of operations on objects that can result in changes in the spatial arrangements of things – the body and external objects. These interventions extend over time and decomposing a current activity into a sequence of actions can be approached in multiple ways. By studying worker behavior in work situations, EWA broadens the understanding of how they truly perceive their problems, identifies obstacles to how activities are carried out, and enables their removal through ergonomic action.

For Wisner (1995), activity is a system of human, individual and social performance, through which subjects work to achieve an outcome. It is dynamic and multifaceted, exhibiting variations in content and form. Any activity performed by a subject includes objectives, means, the process of shaping the object, and results. Objectives appear as the anticipated outcome of creative effort. When performing the activity, the subjects also change, and social conventions manifest themselves through the construction of new forms and characteristics of reality. From an activity theory perspective, cognition mobilizes unconscious mental models that automatically unfold over time, as well as conscious cognitive actions, both of which are interdependent and mutually influential.

Activity is a goal-oriented system, representing the conscious envisioning of a desirable outcome. The task consists of the cognitive and motor actions, operations, and processes necessary to achieve this goal. The complexity of the task is determined by the number of elements in the system, the specificity of each element, the way they interact, and the different ways in which the system can function.

Ergonomists should remain as close as possible to work situations, observing the activity and validating recommendations directly with workers. The EWA approach provides tools to define and describe explicit groups and responsibilities for workers and ergonomists during the analysis. The goal is to reduce tensions during ergonomic intervention, with workers integrating into the group that develops solutions, and ensuring the continuous flow of information about how work situations will be transformed.

The CWA and CTA emphasize identifying intrinsic constraints to work and analyzing how these constraints affect workers' behavior. EWA also considers the influence of the physical environmental components on worker discomfort and the impacts of changes – not only through the inclusion of new technologies, but also by transforming the overall work environment, influencing movements, postures, processes, tools, and equipment.

Difficulties in work situations, workers' perceptions, strategies adopted to meet work demands and potential risks involved in task performance exacerbate the gaps between WAI and WAD. To describe social relationships in healthcare settings, we must have a deeper understanding of interactions involving multiple teams with overlapping or competing interests. Situated cognition is the foundation for activity, particularly in complex situations.

In general, organizations develop work systems and support technologies based on the assumption that systems must be constant in terms of structure, time, and demands. However, in reality, dealing with variations requires continuous performance adjustments, and task sequences can vary significant and rapidly, both individually and among groups of workers. In these cases, performance risks may arise due to the high degree of indeterminacy of task demands and the adjustments required to manage variability.

If systems do not allow workers to recognize important signals that could inform their decisions, function analysis should focus on cognitive issues in a broader sense, rather than viewing humans solely as information-processing units or focusing only on physical constraints affecting performance. To access workers' situated cognition – and therefore their intelligence – a detailed observation of their behavior is essential.

Thus, EWA generates analytical methods and results that align with system variability analysis and, most importantly, provide insights into the possibilities of reconciling WAI and WAD – one of the basis for resilient performance.

Summary

From Activity Theory, which describes people's actions in a holistic context – contrasting with Taylorism's prescriptive approach to human work – we present in this chapter various methodologies, techniques, and tools that can be used for analyzing, evaluating and even designing resilient systems.

Several disciplines related to human factors, such as Ergonomics, Function Analysis or Cognitive Tasks and Cognitive Engineering, have developed a range of techniques that serve as a foundation for addressing Work-as-Done (WAD). As we have seen, WAD provides insight into how people navigate variabilities in their daily work.

All these methodologies, techniques, and tools are widely applied in the analysis and assessment of resilience in complex systems. It is important to note that while the same techniques can be used across different disciplines, the analyst's objective when observing work activities varies. For example, in Ergonomics, the primary focus is typically on adapting work to individuals' physical or cognitive abilities. Cognitive Task Analysis seeks to model cognition at work, while Cognitive Engineering concentrates on developing cognitive systems (joint cognitive systems). Resilience Engineering, in turn, aims to understand how people – and, more broadly, systems – manage unexpected situations.

In the next chapter we will introduce the Functional Resonance Analysis Method (FRAM), a system modeling and analysis approach developed from the principles of Resilience Engineering. This method has been widely applied, including in the field of public health.

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Chapter 12

The Functional Resonance Analysis Method (FRAM)

Adaptive and proactive behaviors continuously shape systems, and modeling this variability is the first step towards making systems more resilient.

The Functional Resonance Analysis Method (FRAM) was designed to model complex sociotechnical systems based on the analysis of functions and their couplings, providing discussions and reflections on variability among specialists and workers, including how variabilities may (or may not) be critical to the system's resilient performance (Hollnagel, 2017).

FRAM focuses on analyzing the actual functioning of systems – the day-to-day work (WAD) and its interaction with prescribed or imagined work (WAI) – which results in variability in function outputs. The analysis of these variabilities introduces the concept of resonance between system functions, meaning that the final outcome depends on how variability in one function's output affects the input of subsequent functions.

FRAM modeling provides a detailed description of the variabilities, offering recommendations to mitigate undesired ones and incorporate beneficial ones. According to its creator, Erik Hollnagel, FRAM analysis consists of the following steps:

- Identify and describe essential system functions, and characterize each function using the six basic characteristics (aspects);
- Check the completeness / consistency of the model;
- Characterize the potential variability of the functions in the FRAM model, as well as the possible actual variability of the functions in one or more instances of the model;
- Define the functional resonance based on dependencies / couplings among functions and the potential for functional variability;
- Identify ways to monitor the development of resonance either to dampen variability that may lead to unwanted outcomes or to amplify variability that may lead to wanted outcomes.

Hollnagel defines functional resonance as the unexpected effect that can be identified in a function output when unintended interactions between two or more functions occur, for example, or when their functioning exhibits undesired behavior, impacting system performance.

FRAM is based on four basic principles:

- Equivalence of Successes and Failures: failure is often explained by the malfunction of a system or its components. However, in a FRAM analysis, things go right and wrong in essentially the same way. The fact that outcomes differ does not necessarily mean that the underlying processes – those leading to success or failure – are inherently different;
- Approximate Adjustments: working conditions never fully align with what has been prescribed. Individuals, groups,

and organizations continuously adjust their performance to accommodate existing conditions and available resources, which are always finite, limited, or under-specified. As a result, these adjustments are approximate, producing variable outcomes that generally aim toward the desired objective. Variability is what makes things work, but it is also what can lead to failure;

- Emergence: the usual variability in performance is rarely significant enough to cause an accident on its own. However, when variability across multiple functions combines in unexpected ways, it can lead to severe consequences. Failures, like normal performance, are emergent phenomena – meaning they do not stem solely from the malfunction of individual system components;
- Functional Resonance: variability across multiple functions can sometimes resonate, meaning the functions reinforce each other in unexpected and undesired ways, amplifying the variability of a particular function. These effects can propagate through couplings within the system, potentially leading to complete system failure.

An advantage of FRAM over traditional models is that it enables the development of a broad understanding of how a sociotechnical system operates, allowing for the identification of both how it should and should not function. In a FRAM model, the system is not viewed as an aggregation of components but rather as a combination of interconnected functions that must be activated to achieve specific objectives. This perspective offers a more comprehensive understanding of system behavior, which is essential for analyzing how resilient performance develops.

The first step in FRAM modeling is to identify the functions necessary for the system's day-to-day operation. Each function will be represented by a hexagon, with its vertices capturing different aspects – temporalities, controls, features, preconditions, inputs and outputs –, as illustrated in Figure 2. Since FRAM is a qualitative method, information about roles is typically gathered through interviews with workers or direct observation of activities.

In a FRAM model, there are two types of functions. The foreground functions are those integral to the system and carried out by workers in their daily activities. Background functions, on the other hand, exist solely to provide inputs for foreground functions, and are typically associated with high-level management, government actions, and policies. To visually distinguish them, background functions are represented by rectangles, or dark-colored hexagons, while foreground functions are shown in lighter-colored hexagons.

The next step is to describe the essential aspects required for a function to be performed successfully, starting with its inputs and outputs. It is not necessary to fill in every aspect; instead, the analyst should focus on those that are detected through the chosen data collection procedure.

For a FRAM model to be complete, each described aspect must be linked to another function. This means that the output of one function should ideally serve as an aspect of another. Functional resonance emerges from these couplings between functions, where variabilities occur. It is important to note that FRAM models allow for different instantiations (couplings), revealing various possible modes of operation within the same system and, consequently, different resonance possibilities. If a function is only needed as a source of outputs that serves as aspects of another function, it is classified as a background function.

Figure 3 illustrates the FRAM notation, where functions are represented by hexagons with their aspects (inputs, outputs, temporalities, controls, features and preconditions) positioned at the vertices. Lines connecting the outputs of one function to the aspects of others represent couplings, which exhibit variability (V). Typically, it is not necessary to characterize variability for background functions, as they generally do not vary on the same timescale as system functions.

In defining the terms that describe the flow of the couplings between the functions of the systems, Hollnagel makes an analogy with the flow of water in rivers. The normal flow, forward, is called downstream. In the opposite direction, the flow is upstream.

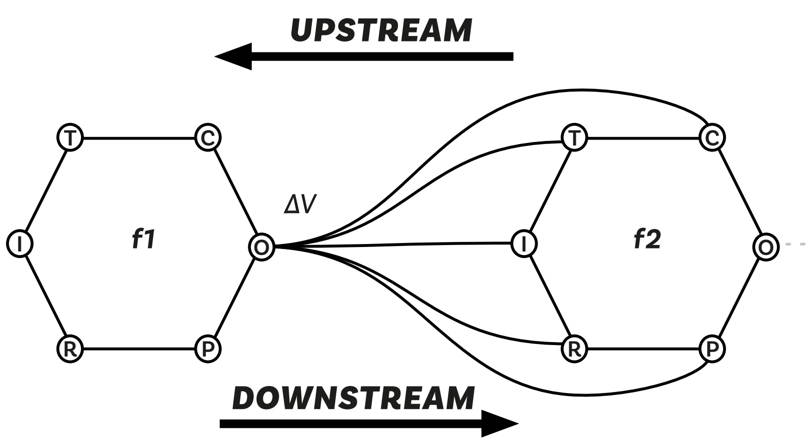

Figure 3: FRAM Notation.
Source: The authors.

Figure 4 illustrates the FRAM modeling of a domiciliary visit planning process carried out by community health workers (CHWs) in a community in the Municipality of Rio de Janeiro. This example drawn from a study published in the journal *Cognition, Technology & Work*, demonstrates how FRAM can be applied to a highly variable work process – not only across different territories, but also among CHWs themselves (Jatobá *et al.*, 2018).

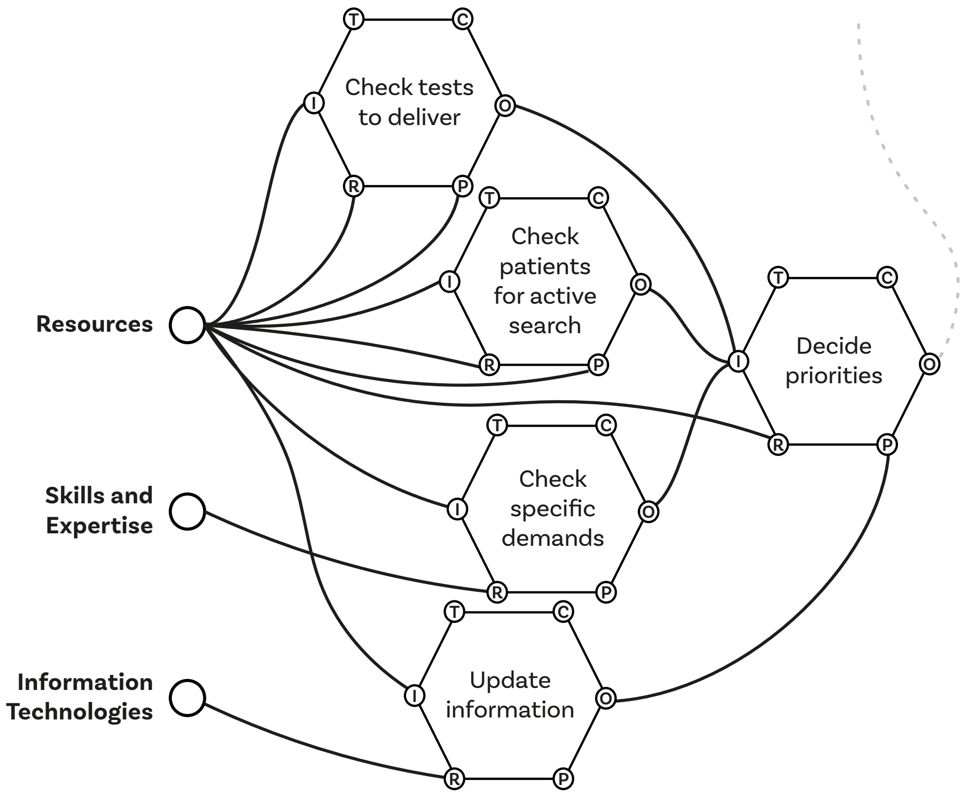

Figure 4: FRAM model of domiciliary visit planning
Source: Adapted from Jatobá *et al.* (2018). Authors' translation.

Although the roles, tasks and responsibilities outlined in the PNAB (Brazilian National Primary Care Policy) establish protocols for domiciliary visits, and, to some extent, reflect a portion of the work as done (WAD), the work environment ultimately shapes the behavior of health professionals. This influence is particularly strong in socially vulnerable regions, where CHWs' activities depend on the conditions of the territory and the needs of its residents. As a result, the PNAB task descriptions cannot fully capture what CHWs actually do but rather prescribe what they *should* do under stable conditions – that is, the work as imagined (WAI). Since care is provided under highly variable conditions, it is difficult to predict exactly how CHWs will operate in different territories. Furthermore, behavioral factors such as fatigue, emotions, past experiences, and cultural background significantly affect their work dynamics, regardless of the territory.

In the model presented in Figure 4, three background functions – represented by small circles – provide the initial inputs for the essential functions involved in the home visiting process. Planning these visits requires multiple decisions made in collaboration with the rest of the healthcare team. Before visiting patients, CHWs must check for pending test results to deliver, identify individuals requiring active searches, and assess many specific demands. The accuracy and timing of these verification functions vary depending on the CHW's experience and skills, particularly their knowledge of and bond with the families they serve.

A similar dynamic applies to the *Define Priorities* function. Understanding a family's structure and conditions determines the route and order of visits, and this knowledge is acquired through relationships built over time. This tacit element underscores the importance of hiring CHWs from the communities they serve, as recommended by the PNAB.

To illustrate the functional resonance involved in executing domiciliary visits, Figure 4 shows how variability in territorial conditions influences the functions performed by CHWs, especially when interpreting local conditions and prioritizing visits. This process of *sensemaking* incorporates various factors, such as violence, terrain conditions, and weather (heat/rain).

To navigate these challenges, CHWs often perform functions not anticipated in the general model, adapting their usual work processes. This is evident in the *Follow Route* function, highlighted in Figure 5. The ability to carry out these adaptations depends on the emergence of additional background functions – that is, organizational support beyond what is initially outlined in the general work model.

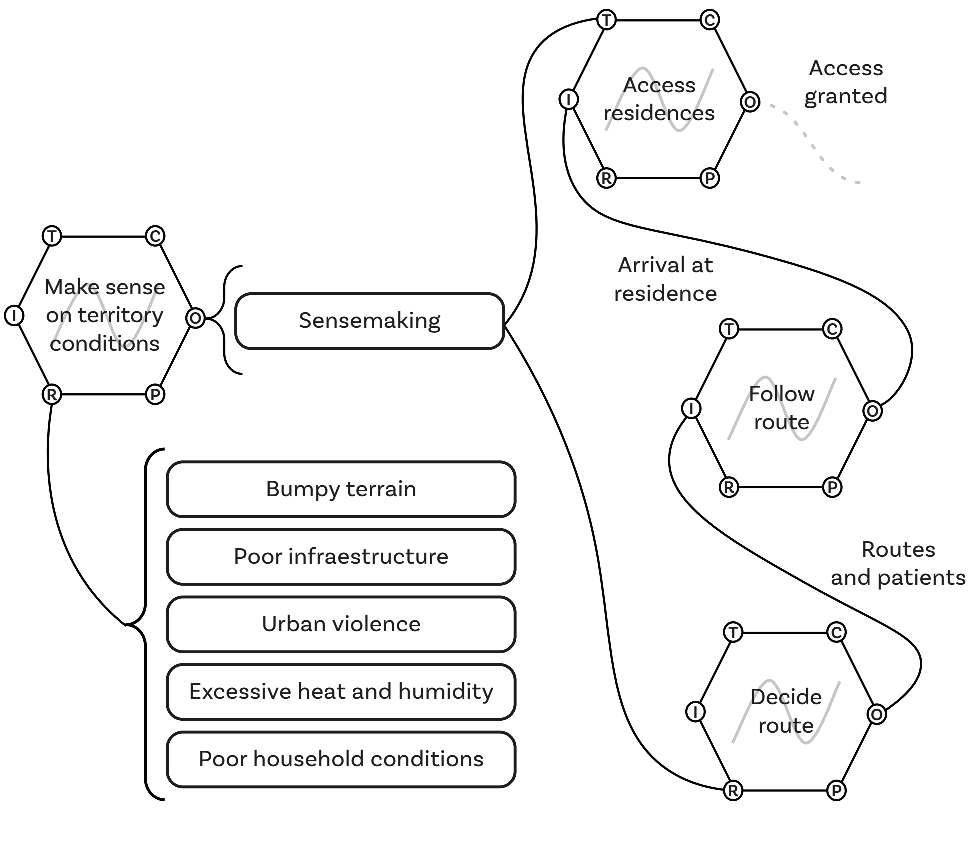

Figure 5: Variability in Domiciliary Visit Planning Modeled with FRAM.
Source: Adapted from Jatobá *et al.* (2018). Authors' translation.

Prospective analyses with FRAM

The purpose of a prospective analysis is to predict a set of events that may impact the functioning of a system. This type of analysis is highly valuable in the health planning process, as it enables the explicit description of different ways to manage the uncertainty and risks inherent to this type of organization. By doing so, various strategies can be developed, enhancing resource mapping and allocation to strengthen adaptive capacity, address unforeseen challenges, and minimize risks.

Investigations of adverse events focus on identifying the causes of undesired outcomes, aiming to determine what actions went wrong. The logic is quite simple: if a particular event (or series of events) had not occurred, the accident would not have happened either. Therefore, this event is considered the cause of the accident. Hollnagel refers to this type of reasoning as the counterfactual approach.

> *A situation or event that did not happen but could have is called a counterfactual. In contrast, the event that actually occurred is referred to as the current one. A counterfactual event belongs to a possible world that contradicts some aspect of reality, whereas the current event exists within the real world.*

The FRAM analysis illustrates the system's daily functioning and represents what happens when it operates effectively. Only by understanding regular functioning we can identify the factors of potential (what could happen) or actual (what was observed in the analysis) variability in functions that may eventually hinder the system's correct operation. While FRAM typically focuses on pre-existing variability, it also enables prospective analysis of potential variability and its effects under different operating conditions.

Success or failure are possible outcomes of FRAM functions, as scenario changes can alter how the system behaves. An instance of the FRAM model serves as an initial representation of how potential variability can materialize in a given situation, demonstrating how functions interact and resonate during normal operations. This provides a model of expected couplings – whether favorable or not – based on the scenario being analyzed. Identifying the couplings that played a specific role in an event helps explain why and how it unfolded, making it possible to reinforce or mitigate these interactions.

In prospective analyses, the focus is on understanding risk. This involves identifying operational modes that may prevent the system from fulfilling its purpose and, if possible, assessing the likelihood of such occurrences. In this context, FRAM can be used to examine whether combinations of multiple preconditions or features generate variabilities and resonances that may weaken a system's design, and whether a lack of control or time constraints might impede intended operations.

By emphasizing the system's functional organization, FRAM differs from traditional risk assessments, which typically focus on identifying and mitigating hazards within constituent elements. Instead of analyzing a predefined event path and calculating the probability of specific failures or actions, FRAM seeks to understand how a situation may evolve through the system's functions and their possible outcomes. It does so by identifying the couplings and resonances between functions. According to Hollnagel, a prospective analysis using FRAM consists of the following steps:

- Characterize the (potential) variability for a set of model instances;

- Identify the couplings likely to influence an event. These include one or more instantiations of the model that help predict how an event may unfold;
- Determine unique or specific outcomes, explaining them based on everyday couplings rather than failures;
- Propose ways to monitor variability.

An extensive study examined the activities of Mobile Emergency Care Service (SAMU-192) teams in riverside regions of Brazil. The research focused on understanding system interdependencies and describing the variabilities in its normal functioning based on effective practices. The goal was to prevent or dampen disruptions that could impact SAMU-192 professionals, thereby enhancing the system's resilience and overall performance (Arcuri *et al.*, 2022).

Urgent care and patient transportation in riverine communities of the Upper Amazon River are possible not only because SAMU-192 professionals follow prescribed rules but also because they continuously adjust their performance based on available resources. The study by Arcuri and colleagues (including Erik Hollnagel himself) highlighted how performance variability – manifested through function-dampening mechanisms – is crucial for building resilience, enabling urgent care in regions with limited access and scarce resources.

After analyzing the regular functioning of SAMU's rescue teams, FRAM was employed to construct a prospective scenario that anticipated system difficulties under stressful conditions. This approach effectively predicted how emergency care for the riparian population would be compromised during the peak of the COVID-19 pandemic. The findings revealed that even minor shifts in variability dynamics could have significant consequences for patient care and the safety of expeditions to vulnerable locations. The system's pre-existing fragility was particularly evident in dealing with acute stress situations, such as COVID-19. Additionally, essential factors that enhance system resilience – such as extra-organizational support from riverside communities – were threatened during social distancing measures, weakening the informal support networks on which the service typically relied.

Figure 6 presents a portion of the prospective model developed for the study, illustrating a complex network of potential functional couplings:

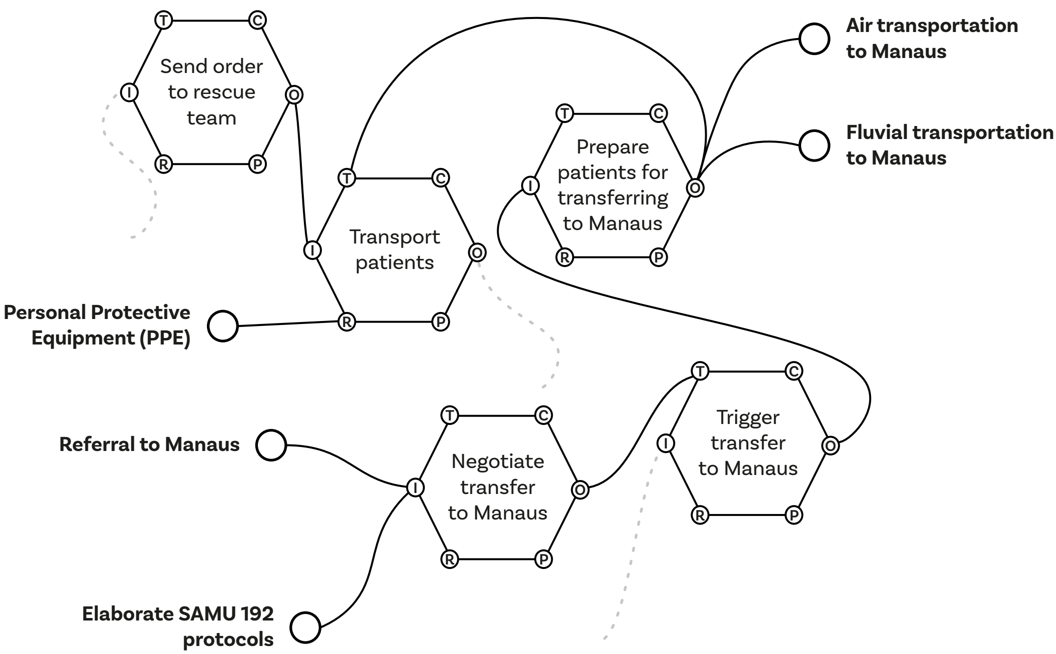

Figure 6: Example of Prospective Analysis with FRAM.
Source: Adapted from Arcuri *et al.* (2022). Authors' translation.

The shift in focus proposed by Resilience Engineering, which FRAM effectively represents, extends beyond analyzing failures during crises. It involves a detailed examination of the system's normal functioning, recognizing that variability – even when its effects are barely perceptible – is a natural outcome of highly dynamic conditions. This deeper analysis of routine operations allows us to understand how small variabilities, which typically do not disrupt performance, can interact, create resonances, and potentially lead to system instability.

Thus, strengthening the adaptive capacity of systems must be a deliberate and informed effort. Rather than solely searching for errors, we should focus on performance adjustments, regardless of their effects. This approach will inevitably highlight conditions that support the necessary adaptations to establish or sustain good – or at least satisfactory – working conditions, compensate for resource gaps, and prevent harmful situations.

It is also important to note that work descriptions – often obtained through interviews – are usually based on perceptions of how a task should be performed (Work-as-Imagined, or WAI). In contrast, observing real-world practice and analyzing work as it is actually carried out (Work-as-Done, or WAD) in routine situations often reveals factual insights that may differ from the intended framework, offering valuable reflections on organizational culture. Therefore, the focus of analysis should be on how the system operates smoothly, rather than only on events that cause exceptional operational disturbances.

Summary

In this chapter, we have explored the Functional Resonance Analysis Method (FRAM) in detail, along with its application examples. FRAM provides a way to describe a system's results and functions using the concept of resonance, which arises from the variability of everyday performance. As a systems modeling meta-methodology, FRAM relies on work analysis methodologies and techniques for its development, such as those described in Chapter 11.

By recognizing that variability in function outcomes can be both positive and negative, FRAM introduces a new perspective to work analysis disciplines, which have traditionally viewed any deviation from prescribed procedures as something to be avoided or eliminated. The idea that people can generate both positive and negative solutions during work – including restructuring processes and even the system itself – is fundamental to studying the resilience or fragility of health systems.

The next chapter introduces four essential skills that systems must develop to enhance resilience or, at the very least, facilitate it. Additionally, a method for assessing a system's resilience potential will be described, illustrated through an application in SUS (Brazilian Unified Health System).

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Chapter 13

The Four Cornerstones of Resilient Performance

A resilient system manages to combine all its potential attributes and abilities – whether material or human resources – in a controlled manner, even in unexpected situations.

The resilience of health systems is reflected in their capabilities and in how they respond to unwanted and/or unexpected situations. This response is supported by the system's various resources, which it mobilizes when needed to maintain essential functions – or even to create extraordinary ones. Therefore, using the terms "resilient behavior" or "resilient performance" helps avoid the misconception of resilience as a simple, binary attribute that can be assessed with a mere "yes" or "no".

This perspective is central to the Resilience Engineering approach and is crucial when analyzing the everyday functioning of health systems. It is also embedded in the institutional capacity of public health systems, which are in constant evolution. This continuous change enables the identification of both immediate and long-term demands in organizations that must constantly navigate adverse, unwanted, and unexpected situations.

Additionally, health systems must ensure that certain functions remain fully operational, even when resources are concentrated on responding to a sudden crisis. The ability to sustain essential health functions under stress is the primary expression of adaptive capacity. This adjustment is typically reactive, often developed *ad hoc* in response to unforeseen events. However, no matter how swift, a reactive response may still be insufficient to prevent the system from degrading to a critical level, jeopardizing some of its essential functions.

No matter how robust, a system not designed for resilience can only respond to a predefined set of anticipated events, making it difficult to manage unexpected crises due to a lack of resources for a more resilient and less reactive response. This limitation became evident during the COVID-19 pandemic when even well-funded health systems in wealthy countries struggled to prevent high mortality rates.

For resilient performance, a system must be proactive – it must anticipate and adjust before an event occurs, or at least before it escalates. It should transition from a normal operating state to heightened readiness at the first sign of an unwanted or unexpected event. Better yet, it should learn from past experiences to be prepared even before any warning signs appear. Preparedness involves allocating resources to match upcoming demands while maintaining flexibility to activate special functions and expand capabilities as needed. However, this heightened state should not persist longer than necessary, as prolonged mobilization can lead to resource depletion.

This process is iterative, with the system continuously learning from experience. The ability to adapt in response to changes and disruptions allows organizations to use insights from past events to inform structural or functional adjustments, enhancing future preparedness. However, investigations into adverse events often focus only on the immediate causes of specific incidents, which may not be sufficient for preventing future unexpected events. Resilient performance, unlike traditional adverse event or accident prevention models, places everyday functioning and the system's ability to manage disturbances at the core of its analysis.

It is also important to recognize that complex systems, operating within unstable environments, develop skills, potentials, and capacities that reinforce both their enduring and evolving characteristics for resilience. According to this perspective, the resilient performance of complex systems relies on developing four key capabilities, known as the "cornerstones" of resilient performance (Hollnagel, 2016):

- **Respond:** knowing what to do; the ability to respond to both expected and unexpected disturbances and opportunities. This includes mobilizing resources, adjusting workflows, and implementing immediate corrective actions to maintain functionality;
- **Monitor:** knowing what to look for; the ability to track both internal and external conditions that could indicate potential threats or changes. This involves continuous assessment of key performance indicators, early warning signs, and feedback loops to detect risks before they escalate;
- **Learn:** learning from what actually happened; the ability to analyze past experiences, both successes and failures, to improve future responses. Learning ensures that the system evolves over time, refining its processes and structures to enhance resilience;
- **Anticipate:** knowing what to expect; the ability to foresee potential disruptions and prepare for future challenges. This means identifying vulnerabilities, predicting possible failures, and planning proactive strategies to enhance system preparedness.

According to Hollnagel (2016), to adequately respond to both extraordinary and routine demands, it is essential to enhance the system's ability to anticipate what may happen, identify critical factors, and learn from concrete past events. Resilience is inherently multifaceted, encompassing individual, social, and workplace factors.

The ability to respond: understanding what to do

No system can sustain its operation and continue to exist unless it can respond effectively to events, bringing about appropriate changes in the context in which it operates. A resilient system adapts by adjusting its functioning to better align with new conditions, in order to: mitigate the effects of adverse events; prevent further deterioration of its conditions; restore the state prior to the event (when desirable); transition to a state to readiness, and so on. Additionally, for a prompt response when something unwanted occurs, the system must first detect the event, identify it, assess its severity, and allocate the necessary resources and capabilities.

The ability to recognize that something unforeseen has happened depends not only on what the system looks for but, more importantly, on how it perceives such events. This search must be continuous and systematic, based on predefined categories of known critical events or threats, while also remaining open to weak signals that may indicate new possibilities of events.

The detection process is crucial because if the system misidentifies events or threats unrelated to the health problem at hand, it may respond inappropriately, leading to unnecessary resource expenditure or misallocation. Consequently, it risks becoming vulnerable or locked in a state of difficult demobilization, hindering its ability to address the actual event – an issue we explored in the discussion of third-type errors in Chapter 4.

However, resilience is not solely about detecting unforeseen events. Many unwanted events are already mapped and easily identifiable, requiring predefined responses embedded in system protocols and procedures. In some cases, urgency and severity may demand immediate action, which, by its nature, can limit the ability to fine-tune the intensity of the response without compromising other critical functions.

Recognizing and classifying an event's severity serves both to establish a level of preparedness and to guide actions in real-time situations. In the first case, determining whether a response is necessary and what type it should be depends on cultural, organizational, and situational factors.

Finally, ensuring the availability of necessary resources for the chosen response is essential. It is not just about having resources readily at hand – which is crucial for regular threats – but also about whether the system is flexible enough to mobilize new resources when needed and to quickly assess the effectiveness of a response to unexpected events. A deep understanding of the system's functioning and its real conditions in relation to various types of threats is fundamental for the proper allocation and provision of resources.

The ability to define what should be done depends on both the predictability of threats and the resources available. In some cases, system managers may fail to mobilize an adequate response due to a lack of information, insufficient resources, or the perception that the cost of action outweighs the threat's impact. In any case, full readiness is only achievable for regular threats. However, this does not mean that unusual or unprecedented events can be disregarded – they must instead be approached differently.

Monitoring short-term risks

A resilient system must be able to monitor events related to its context, tracking the development of situations that may become critical in the short term. The monitoring framework should be periodically reassessed to prevent control from becoming constrained by routine habits. Otherwise, the system will only be prepared in advance for the most common threats – those that can be recognized ahead of time. It is essential to continuously expand the range of events for which the system can maintain a permanent state of preparedness. The key is to identify and monitor what may soon become critical and use this information to shift from a state of normal operation to a state of readiness whenever conditions indicate an unexpected stress situation.

The state of readiness should not be maintained permanently, as it consumes resources that are essential for the system's normal operation. This is why the ability to monitor is so crucial for an effective response – monitoring enables the system to allocate resources efficiently while sustaining other essential functions. Effective monitoring of critical factors relies on making adequate, reliable, and timely decisions about what may pose health threats in the short term, allowing the system to transition to a state of readiness with enough time to act.

Typically, monitoring is conducted through the evaluation of indicators. In the case of resilience, indicators must highlight the system's potential for resilience – these are known as leading indicators. This requires additional attention, as most management systems primarily provide lagging indicators – those based on past results, such as hospital admissions, the history of procedures performed, or the number of vaccines. While these lagging indicators are useful and necessary, they are not sufficient on their own to illustrate a health system's capacity for resilient performance against future threats.

To make them useful for resilience, analysis techniques are required to anticipate possible improvements and link them to critical events that should be monitored in the short term – such as through trend analysis or simulations.

If resilience involves the ability to adapt operations even before an event occurs, this can only be achieved if attention if paid to what may quickly become critical. The effort must be recognized as worthwhile, the necessary investment in resources must be made, and monitoring must be directed toward the most relevant indicators. Otherwise, the system risks being caught off guard, unprepared at moments when readiness is crucial. COVID-19 has demonstrated that unforeseen situations will always arise, challenging both preparedness and monitoring. However, a resilient system can take steps to reduce the frequency of such occurrences and mitigate their harmful effects.

Anticipating long-term potential threats

While monitoring focuses on short-term threats, it is also necessary to build a state of preparedness for events or crises that may develop over a longer time frame. However, the difference between monitoring and anticipating future events lies not only in their respective time horizons but also in how these abilities are put into practice.

Monitoring involves checking a predefined set of clues or indicators that represent endogenous aspects of the system on a daily basis. If these indicators signal a change in conditions, the system is placed in readiness to respond. Anticipation, on the other hand, involves searching for exogenous causes that indicate potential developments to be avoided. While monitoring is an ability used to track regular threats, anticipation focuses on identifying irregular threats.

There are some similarities between developing the ability to anticipate and traditional risk assessment. However, traditional risk assessment is limited to representations and methods that rely on linear combinations of events, making it unsuitable for scenarios with high potential variability.

Traditional risk assessment is most effective in systems that look for threats within their own functioning, where the gaps between WAI (Work-as-Imagined) and WAD (Work-as-Done) are smaller, or where prescriptions are highly detailed and standardized – such as in industrial sectors dealing with hazardous technologies. In such cases, it may be acceptable to some extent to assess the potential for failure based on known event combinations or linear extrapolations of past incidents. However, in complex and highly adaptive systems like public health, which primarily deal with external threats, anticipation requires imagination – describing the dimensions of preparedness the system must maintain, even when specific future events cannot be fully defined in advance.

Developing the ability to anticipate in health systems is as essential as it is challenging, as it requires identifying both external aspects, such as emerging epidemics, and internal aspects, such as individual and collective work dynamics within the organization. Additionally, balancing the organization of regular work with the necessary adjustments to sustain a state of preparedness for events that may never occur is inherently difficult. Therefore, it is crucial that the analysis of potential events is reliable and based on adequate observations and indicators.

Anticipation is an ability that management often hesitates to invest in, as it involves allocating resources to address events that may never materialize. Moreover, the benefits of anticipation are long-term and uncertain, making it difficult for managers to act within a defined time frame.

Learning from what happened

Learning from experience may seem obvious and natural, but developing resilient behavior requires that this ability be activated systematically, planned carefully, and supported with all necessary resources. In resilience engineering, the effectiveness of learning depends on solid foundations, reinforced by the frequent and systematic selection and classification of events or experiences that must be considered, analyzed, and understood. This process should be guided by the following questions:

- Which events should be investigated, and which should not?
    - Since human, material, and temporal resources are always limited, some level of abstraction is necessary – focusing on what is important and disregarding what is not. This does not mean prioritizing failures over successes; quite the contrary. Similarly, investigations should not be limited to events with severe outcomes while overlooking minor adverse events, such as everyday incidents and unsafe acts without immediate consequences. Furthermore, analysis should not be confined to local occurrences, as external experiences can provide significant learning opportunities.
- How should events be described?
    - Accidents in complex systems do not offer unique or objective descriptions of the events that caused them. Investigating the causes of extraordinary events – especially those with severe consequences, such as major epidemics and disease outbreaks – is always subject to multiple interpretations. The coherence of these interpretations depends on the data collected,

  how they are coded, and how they are analyzed. The underlying assumptions of the chosen analytical method often determine the outcome.

- When and how should learning take place?
  - The key decision here is whether learning should occur continuously or only when specific events happen. If learning is limited to major events, then nothing is gained from those considered trivial, even though they occur more frequently. However, if the goal is to learn from situations that function well, the learning process will naturally become continuous, spanning different periods and contexts.
- Should learning be individual or organizational?
  - Work performance is shaped by a combination of individual skills, institutionalized knowledge, and attitudes. Institutionalized knowledge is typically expressed through rules, regulations, standards, procedures, and policies. Attitudes, in turn, determine how knowledge is mobilized and how rules are followed – whether to achieve individual goals or collective success.

Hollnagel emphasizes that when learning from experience, it is important to distinguish between what is easy and what is meaningful, as experience is often expressed in terms of the frequency with which an event occurs relative to others, particularly those that produce negative effects. In this sense, resilience is the ability to maintain normal functioning, not just to prevent failure. A resilient system should not limit learning to specific categories of events and certainly not only to failures. Event descriptions should go beyond identifying their causes, as in the classic safety approach, and instead encompass how the system functioned during the event.

The four resilience cornerstones or abilities proposed by Hollnagel – anticipation, learning, monitoring, and responding – are clearly interdependent. For example, providing an adequate response is only possible if short-term events are properly monitored or if potential long-term events are effectively anticipated. Moreover, for monitoring, anticipation, and response to be efficient, learning from experience is essential.

The development of learning particularly strengthens the ability to monitor, providing crucial elements for health surveillance, for instance. While learning from past mistakes is important, it is equally necessary to learn from successful experiences that occur on a daily basis. In addition to reviewing actions taken when an incident occurs, the stable functioning of the health system should be continuously assessed so that experiences that support stability can be reinforced.

It is critical to proactively develop a learning and assessment strategy. Learning should enable an understanding of what works and what does not, leading to better planning, recovery, and response. This longitudinal learning offers a broader perspective on how the system functions over time, rather than just during the occurrence of an incident.

The connections between the ability to learn and other abilities, especially monitoring, can yield significant benefits, such as well-structured information systems and effective data collection processes. Strategies for disseminating knowledge, sharing lessons learned, and fostering continuous education enhance the ability to learn by supporting an ongoing process of assessing the impacts, unpredictability, and disproportionate behaviors of potential events related to system nonlinearity.

An interesting approach is to view the four resilience abilities as system functions and, through a FRAM analysis, understand how couplings generate resonance between them, as discussed in Chapter 12. This analysis demonstrates the interdependencies between these abilities while preserving the necessary variability within couplings, allowing for adaptation in each specific case where they are activated. A FRAM model representing the four resilience abilities as generic functions is shown in Figure 7.

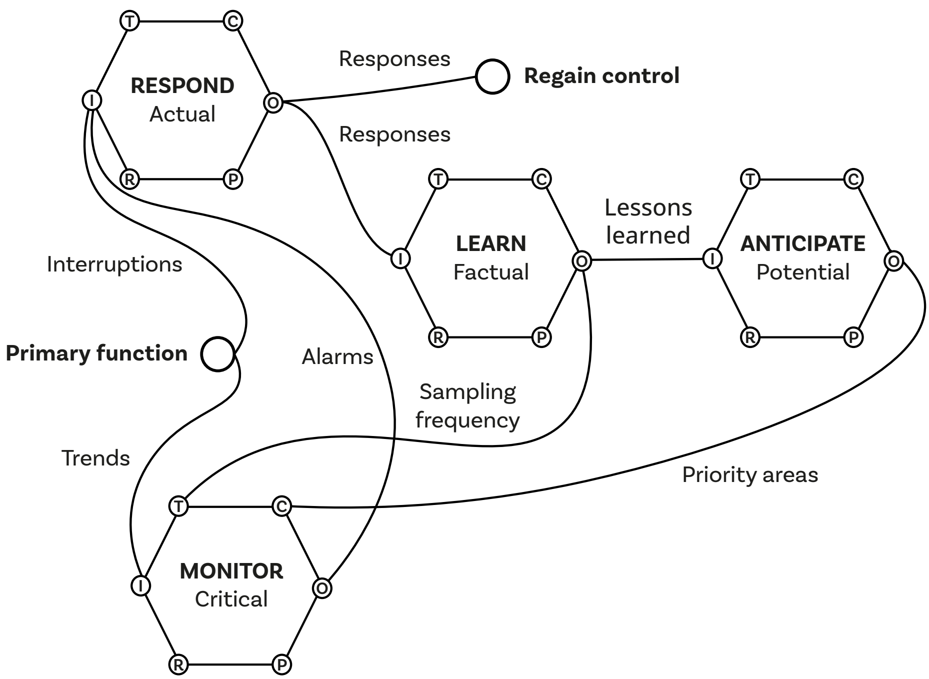


Figure 7: Resilient Abilities as System Functions.
Source: Adapted from Hollnagel (2015).

This model considers full system recovery as a return to its normal conditions (as it was before the event), the expected outcome of an effective response to an unexpected event. However, it is essential to accurately characterize the system's operating conditions before the event. If these conditions are fragile, the most appropriate response should be a positive and lasting transformation of the system – dampening negative variabilities while incorporating new positive variabilities into normal functioning.

The framework for analyzing resilient abilities, proposed by Hollnagel and described in the next section, has shown promising in identifying factors that promote either resilience or fragility in systems. For instance, consistently monitoring a sufficient number of events over time, based on a well-structured set of lessons learned, can generate alarms that prompt timely responses. Additionally, lessons learned facilitate the anticipation of events with disruptive potential, enhancing the accuracy of alarms and improving overall responsiveness.

The Resilience Analysis Grid (RAG)

The Resilience Analysis Grid (RAG) employs sets of questions to assess a system's performance across the four basic potentials. These questions are answered using a Likert-type scale and must be tailored to the specific application (Hollnagel, Braithwaite, & Wears, 2015).

Responses should be both timely and effective to achieve the desired outcome. The system must first detect that something has occurred, then recognize what it is and determine whether a response is necessary. Finally, it should know how to respond, when to initiate action, and when to stop. Flexibility in responses is essential to ensure that resources are available when needed.

Regarding the ability to respond, the RAG lists the following questions:

- **Event list:** What are the events for which the system has a prepared response?

- **Background:** How were these events selected? (tradition, regulatory requirements, design basis, experience, risk assessment, industry standard, etc.).
- **Relevance:** When was the list created? Who maintains and evaluates it? How often and on what basis is it reviewed?
- **Threshold:** When is a response activated? What is the trigger criterion? Is the criterion absolute or dependent on internal/external factors?
- **Response list:** How do you determine what response is appropriate? Empirically, or based on analysis and models?
- **Speed:** How quickly is full responsiveness available? How soon can an effective response be implemented?
- **Duration:** How long can an effective response be maintained? What is the minimum acceptable response level and how long can it be sustained?
- **Stop rule:** When does the system return to normal?
- **Responsiveness:** How many resources are allocated to ensure responsiveness (people, equipment, materials)? How many are unique to the response potential? Who is responsible for maintaining responsiveness?
- **Check:** How is readiness to respond maintained? How and when is this readiness checked?

Resilience is not possible unless the system can monitor both its own performance (what happens within its boundaries) and external conditions (what happens in the environment beyond its boundaries). Effective monitoring enhances the system's ability to address short-term threats and seize opportunities, relying on key indicators to do so.

Regarding the ability to respond, the RAG poses the following questions:

- **List of indicators:** How were the indicators defined? (through analysis, tradition, industry consensus, etc.).
- **Relevance:** Is there a clear justification for monitoring these aspects? Does the list include monitoring related to recent threats? How often is it reviewed and on what basis? Who is responsible for maintaining and evaluating the list?
- **Indicator:** Do the indicators represent single measurements or aggregated data? How many are leading indicators, and how many are lagging indicators?
- **Validity:** How is the validity of an indicator determined? Do the indicators correspond to a well-defined process model?
- **Delay:** For lagging indicators, how long is the typical retrospective period? Is this delay acceptable?
- **Type of measurement:** Are the measurements qualitative or quantitative? If quantitative, what kind of scaling is used?
- **Measurement frequency:** How often are measurements taken? (Continuously, regularly, or intermittently).
- **Analysis/interpretation:** What is the delay between measurement and analysis/interpretation? How many of the measures are directly significant and how many require further analysis? How are the results communicated and utilized?
- **Stability:** Are the effects being measured transient or permanent?
- **Organizational support:** Is there a regular inspection process? If so, is it appropriate?

Both the ability to respond and the ability to monitor rely on the capacity to learn. Efficient and systematic learning from experience requires careful planning and significant resources. The effectiveness of learning depends on the ability to determine which events or experiences should be considered. When learning from experience, it is crucial to distinguish between what is easy and what is meaningful.

Regarding the ability to respond, the RAG outlines the following questions:

- **Selection criteria:** Which events are investigated, and which are not? (e.g., frequency, severity, value). How is the selection made, and what criteria are used? Who makes the selection?
- **Learning basis:** Does the system attempt to learn from both successes (things that go right) and failures (things that go wrong)?
- **Classification:** How are events described? How is data collected and categorized?
- **Formalization:** Are there formal procedures for data collection and analysis?
- **Training:** Is there formal training or organizational support for data collection and analysis?
- **Learning method:** Is learning a continuous process or triggered by specific events?
- **Resources:** How many resources are allocated for research and learning? Are they sufficient? What criteria determine their allocation?
- **Delay:** What is the reporting time of significant events? How are results communicated internally and externally?
- **Learning Goal:** At what level does learning take effect? (e.g., individual, collective, organizational).
- **Implementation:** How are lessons learned applied in practice?

The purpose of observing potential is to anticipate possible future events, conditions, threats and opportunities that may be beneficial or detrimental to the functioning of the system. When systems are very adaptive and, as a result, difficult to specify, traditional risk assessment methods prove to be ineffective. Therefore, to assess the ability to anticipate, the RAG proposes the following questions:

- **Expertise:** What kind of experience forms the basis for anticipating the future?
- **Frequency:** How often are potential future threats and opportunities assessed?
- **Communication:** How are expectations about future events communicated within the system?
- **Strategy:** Does the system have a clearly defined model of the future?
- **Model:** Is the model qualitative or quantitative? Are assumptions about the future explicitly stated or implicitly understood?
- **Time horizon:** How far ahead does the system project into the future?
- **Risk acceptability:** Which risks are considered acceptable or unacceptable, and on what basis?
- **Etiology:** What is the assumed nature of the future? (e.g., threats, opportunities)
- **Culture:** Is risk awareness part of the organizational culture?

The above questions should be tailored to the specific system being evaluated, considering the organization's operations and objectives. For the development of the RAG, Hollnagel recommends conducting interviews or focus groups to collect data. When formulating diagnostic questions, it is important to establish agreed-upon response categories. If there are already known issues with the organization's functioning, efforts should be made to incorporate them under one of the four potentials.

Additionally, it is crucial to develop a specific description or model of the mutual dependencies among the four potentials for the organization being analyzed. In this case, FRAM is the ideal method. This is necessary not only for interpreting the collected data but also for developing responses that align with the organization's reality. While a general model can be proposed as a starting point, it must be adapted to the specific organization, capturing not only the relationships between the four potentials but also how these potentials depend on more detailed functions.

For example, consider using RAG to assess the resilience potential of the patient referral prioritization process when performed by family physicians at the PHC level. In this organizational design, family physicians have the prerogative to directly refer their patients to specialized services such as surgeries, exams, and specific treatments. While these physicians are more attuned to their patients' needs, decentralizing referral prioritization significantly affects care coordination. This shift affects how services are structured to respond and how resources are mobilized to monitor users' conditions.

As Hollnagel suggests, focus groups with experts were conducted to gather information about the activity, complemented by an extensive literature review on the subject. As a result, the instrument shown in Table 1 was developed. For its application, a five-point Likert scale was used:

(5) Excellent: the system meets and exceeds the criteria for required capacity;

(4) Satisfactory: the system fully meets all reasonable criteria for the required capacity;

(3) Acceptable: the system meets the minimum capacity criteria;

(2) Unacceptable: the system does not meet the capacity criteria;

(1) Deficient: The system lacks sufficient capacity.

Dimension	Metrics	What is to be measured
Response	Event list	The system's ability to maintain a list of adverse situations for which the surveillance and control system must have a prepared and formalized response.
	Speed	Speed and efficiency in responding to adverse situations.
	Responsiveness	The existence of resources allocated to guarantee an adequate response, and whether the response guarantees waiting times compatible with patients' needs.
	Communication tools	Transparency and quality of the communication between health professionals and patients.
	Agreement	Quality of collaboration and consensus in decision making.
	Distribution of work tasks	Quality of organization of activities between doctors and other health professionals.
	Interface between systems	Ease of software interoperability.
	Workload	Doctors' and health professionals working hours.

Dimension	Metrics	What is to be measured
Monitoring	Monitoring internal management indicators	How often management indicators are analyzed and updated.
	Queue management	Frequency of review of the waiting list and unmet demands.
	Documentation	Follow-up by the health teams for ongoing procedures and registration of the population.
	Prioritization process	Reliability of the data used by teams to monitor health situations to define priorities.
	Territorial dynamics	Level of understanding of health teams about the changing conditions in the territory.
	Flow	Ability of the Health Unit to track patients position in the health system.
	Access indicators	Quality, reliability and speed of retrieval of access indicators.
	Continuous improvement	Periodic review of the processes for collecting and using indicators.

Dimension	Metrics	What is to be measured
Learning	Selection criteria	Quality of the criteria for selecting important events for organizational learning.
	Learning basis	Quality of the process of cataloging relevant events.
	Leadership	Legitimacy of leaders and their ability to transmit experiences to other team members.
	Continuing education	Quality of the learning process.
	Resources	Availability of material and financial resources for learning.
	Focus on Learning	Clear definition of the objectives and target audiences of the learning process.
	Implementation	Frequency of use of lessons learned in the formulation and revision of regulations, procedures, standards, training and instructions.
	Training	Training the teams to carry out their tasks based on the lessons learned over time.

Dimension	Metrics	What is to be measured
Anticipation	Time management	The ability of health professionals and teams to self-manage their workload and guarantee specific times to access health services.
	Prospecting	The ability of teams to predict future scenarios involving extraordinary situations or demands.
	Integrality	Planning for care coordination according to the particularities of the territories and the specific needs of their patients.
	Communication	Quality of dialogue between family doctors regarding the conditions of their patients and the organization of the waiting list.
	Risk assessment	Reliability of the criteria that define which risks are considered acceptable and which are unacceptable.
	Documents and Protocols	Clarity and dissemination of referral and access protocols.
	Contingency of resources	Ability to mobilize additional resources to respond to new events and sudden events.
	Situational awareness	Level of perception of the risks of adverse situations.

Table 1: Tailored RAG for Assessing Resilience of Decentralized Referral Prioritization.
Source: The authors.

The final scores of each resilience potential are presented in the radar plots shown in Figure 8, providing a visual representation of the resilience profile.

Scores were determined based on the proportion of the radar coverage area, where the axes correspond to the indicators used to assess each ability. A higher percentage of covered area indicates a greater resilience potential.

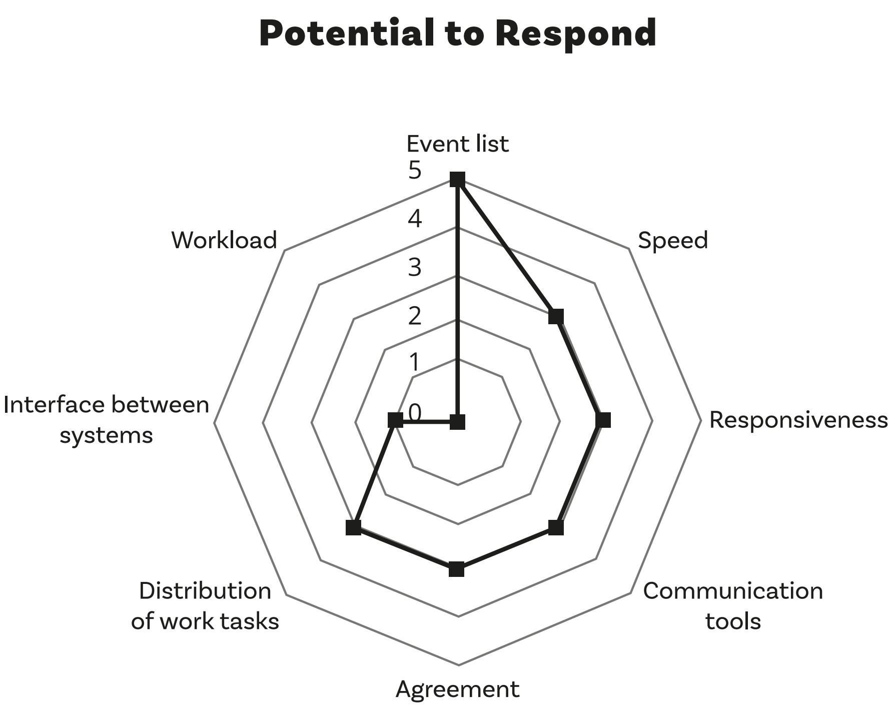
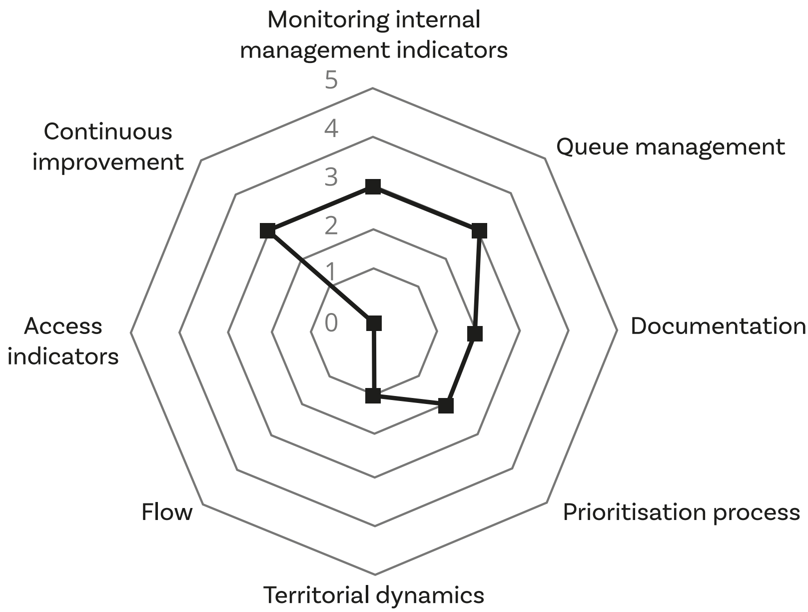
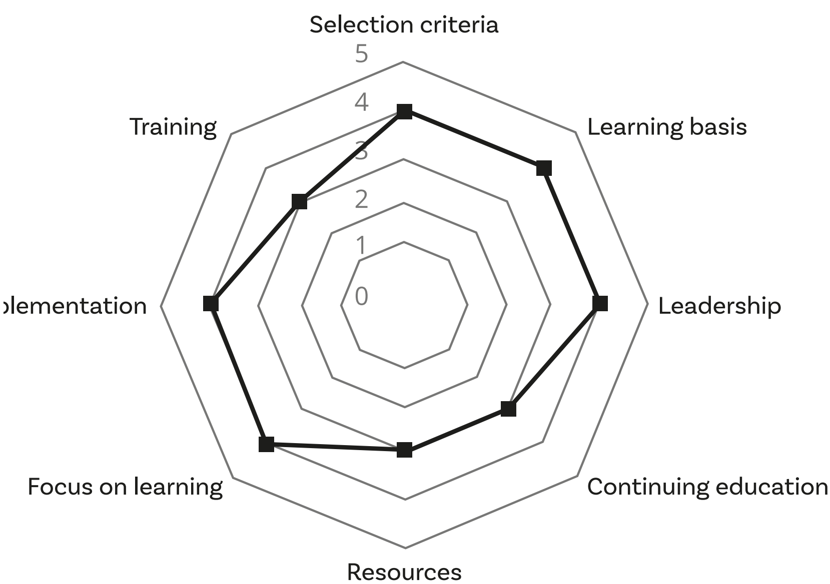


Figure 8: RAG's Radar Charts.
Source: The authors.

Potential for Monitoring



Potential to Learn



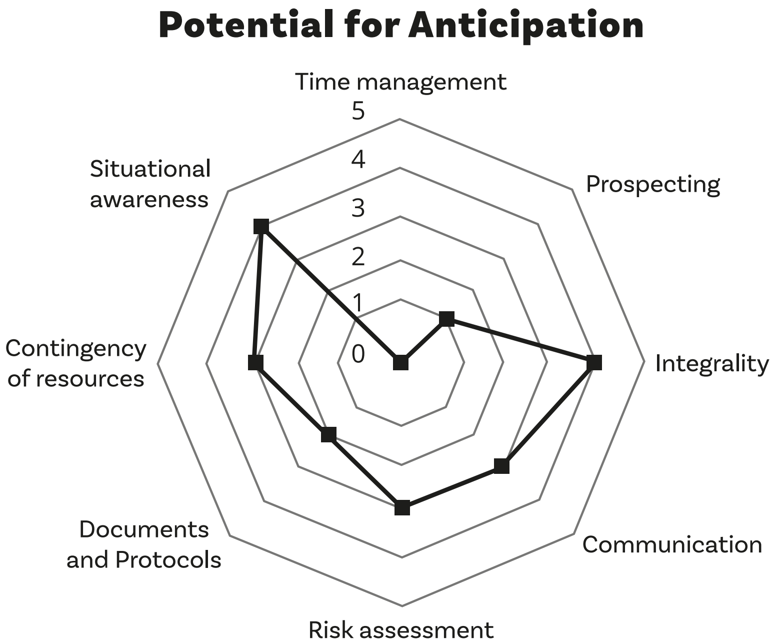


Figure 8: RAG's Radar Charts.
Source: The authors.

Summary

In this chapter, we present the four abilities essential for resilient performance and the Resilience Analysis Grid (RAG), a tool that utilizes sets of questions to assess a system's performance across the four basic potentials proposed by Hollnagel (2015). The RAG enables the evaluation of how individuals within an organization or healthcare service perceive the development of abilities for resilient performance.

In most socio-technical systems, the ability to adapt and respond to unexpected situations still relies heavily on workers. Therefore, it is crucial to understand how people in a given organization perceive cultural, personal, organizational, and technical conditions in relation to developing resilience capabilities.

Through RAG analysis, organizations can identify areas within their culture, structure, training, or management that require improvement to foster resilient performance.

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Chapter 14

Essential Public Health Functions from a Resilience Perspective

The robustness of a health system alone is not enough to make it resilient. It is the abilities, proactive mindset and adaptive behaviors of workers, and governance arrangements that ensure the continuity of essential functioning during crises.

Resilience offers a new perspective on the performance of health systems as sociotechnical systems. Traditionally, these systems have been analyzed based on their constituent parts – for example, hospitals (number of beds, hospital production), outpatient coverage, etc. While the structural aspects of a system cannot be ignored, resilience emphasizes not only how this structure is built but also how it operates. More specifically, it considers how the system's functions are organized to make use of its installed capacity. In this chapter, we introduce a new dimension: What functions must a health system contain to be considered resilient?

Essential public health functions have been identified for a long time. Charles Winslow proposed an inventory of basic functions for the sector as early as the beginning of the twentieth century (Winslow, 1920). While there has been broad consensus on Winslow's proposed roles, their practical application within government, the private sector, and society has evolved significantly since then. For example, until the mid-twentieth century, these functions were largely limited to sanitation, basic hygiene, and communicable disease control. Over time, the scope of public health expanded to include areas such as health promotion, non-communicable disease control, and access to primary health care (PHC). In response to this growing conceptual complexity, various health authorities have developed inventories of public health functions tailored to their regional realities.

The WHO published its first inventory of essential public health functions in 1997, largely in response to the dissolution of the Soviet Union and the subsequent breakdown of health services in the region. Newly independent states, many with little or no experience in public health governance, sought WHO's guidance in identifying key functions indispensable for achieving health sector goals. Around the same time, in 1994, the CDC in the United States also developed its own list of essential public health services (World Health Organization, 2018).

Since the late 1990s, four WHO regions – Europe, the Western Pacific, the Americas, and the Eastern Mediterranean – have established their own lists of public health functions. However, recent global health crises, including the H1N1 influenza outbreak in 2009, the Ebola epidemic in West Africa in 2014, the Zika virus outbreak in the Americas in 2016, and most notably, the COVID-19 pandemic, have underscored the urgent need to reassess these inventories. Strengthening public health functions is now seen as crucial for building more resilient health systems, achieving universal health coverage, and aligning with the Sustainable Development Goals (SDGs) outlined in the 2030 Agenda (UN, 2017).

The COVID-19 pandemic had a particularly severe impact on the Americas, especially in Brazil, which became the second global epicenter of the disease. Between the first recorded case in March 2020 and December 2022, the country approached 700,000 deaths. This crisis underscored the need for PAHO to strengthen essential public health functions for resilience, as the daily lives of people worldwide were disrupted in an unprecedented way. The pandemic exposed weaknesses in health system resilience, where fragmentation and inequality hindered effective responses to public health needs – even under normal circumstances – leaving the most vulnerable sectors of society disproportionately affected by COVID-19.

To support Member States in developing comprehensive health sector plans and policies, PAHO published a new inventory of essential public health functions for the Americas in 2020. This updated framework emphasizes resilience and aligns more closely with the SDGs and the principles of Universal Access to Health and Universal Health Coverage promoted by WHO. By adopting this framework, Member States can develop integrated public policies and strengthen the resilience of their health systems at various levels of care, adapting to the specific contexts and needs of each region (Pan American Health Organization, 2020).

PAHO's proposal outlines essential public health functions for the Americas across four stages – assessment, access, policy development, and resource allocation, as illustrated in Figure 9.

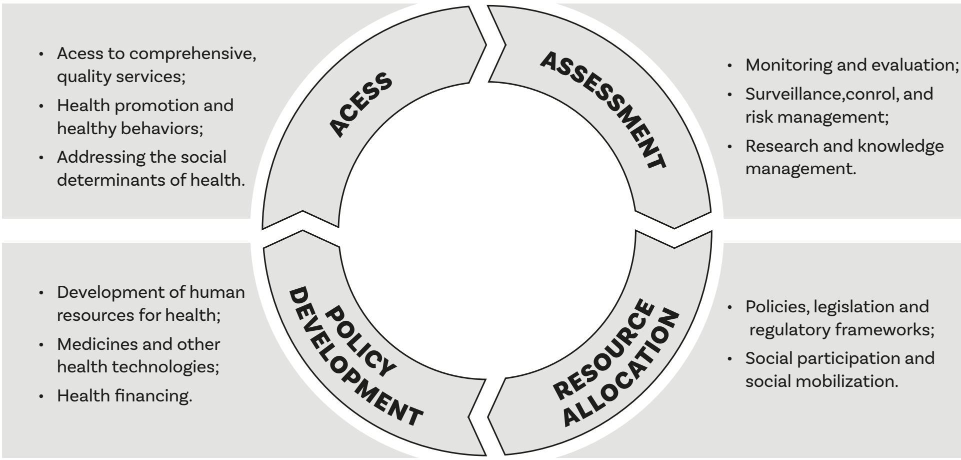

Figure 9: The Essential Public Health Functions.
Source: Adapted from Pan American Health Organization (2020).

Assessment stage

This stage encompasses functions related to evaluating, researching, and monitoring the health status of communities and populations, as well as analyzing inequalities and the factors contributing to precarious conditions, including social determinants of health. These functions are essential for strengthening intelligence through population health analysis, health system performance monitoring, and research. Empirical data gathered during these processes provide evidence of the effectiveness of health policies and the system's ability to meet population needs. This serves as a foundation for policy development and requires community mobilization and public education on health issues.

- Monitoring and evaluation of health and well-being; equity; social determinants of health; and health system performance and impact;

    - This function ensures the availability, analysis, and use of information regarding population health status and well-being, health equity, social determinants of health, and the responsiveness of the health system. It also covers public health interventions at both the population and individual levels. The goal is to enhance the capacity of health authorities to implement monitoring and evaluation processes, including the use of information technologies, data management, forecasting, and scenario modeling. Additionally, it supports the analysis and application of this information in health policymaking and sector planning to address population health needs effectively.

- Public health surveillance, control and management of health risks and emergencies;
    - This function focuses on strengthening the institutional and management capacities of health authorities to ensure adequate surveillance, control, and response to health risks. This includes outbreaks of communicable diseases, health emergencies, and risk factors associated with non-communicable diseases, mental health, and injuries, among other concerns.

- Promotion and management of health research and knowledge.
    - This function involves generating scientific knowledge and integrating it into health policy processes to provide essential contributions toward strengthening health systems and public health initiatives.

Policy development stage

At this stage, the functions focus on developing technical capacity for formulating public policies aimed at improving population health, with an emphasis on interventions that address the root causes of precarious conditions and strengthen local systems. This also includes mechanisms to ensure that key actors can actively participate in decision-making and accountability processes that support the implementation of strategies to enhance health systems.

- Development and implementation of health policies and promotion of legislation to protect the health the population;
    - This comprises two components: strengthening the capacity of health authorities to formulate and implement sectoral policies based on the best available knowledge and enhancing their influence on the production of laws that establish a formal regulatory and institutional framework for the health sector. Both components should be guided by the principles, assumptions, and objectives of advancing universal access and coverage while reinforcing the institutional structure of the health sector to effectively address the challenges and needs of the population.

- Social participation and social mobilization, inclusion of strategic actors, and transparency;
    - This role involves civil society acting with the necessary capacity, skills, and opportunities to identify problems and needs, set priorities, and deliberately and democratically formulate and negotiate its health development proposals. It encompasses collective actions through which organized civil society

actively intervenes and influences the organization, social control, management, and oversight of health organizations and the health system as a whole.

Resource allocation stage

The functions in this stage pertain to the implementation of policies aimed at strengthening both formal and informal institutional arrangements and mechanisms that influence the coverage and allocation of critical health system resources, including financial and human resources, as well as health technologies.

- Development of human resources for health;
    - This includes implementing policies, regulations and interventions related to vocational training, employment and working conditions; internal and external professional mobility; education and professional practice; and distribution of human resources for health. Although these actions fall under the management of health authorities, this function also requires strategic planning and the technical and political capacity to design and implement synergistic interventions across different health sectors, each involving multiple stakeholders with specific responsibilities, objectives and interests.
- Ensuring access to and rational use of quality, safe, and effective essential medicines and other health technologies;
    - Equitable access to medicines and other health technologies is a global priority that was formally recognized in 2016 as part of the SDGs. This function underscores

the importance of both access and rational use of medicines and other essential health technologies, outlining how countries can ensure availability through various public policies.

- Efficient and equitable health financing.
    - This function encompasses all aspects of the financing process, extending beyond the health sector budget to ensure two key contributions. First, it incorporates the various functions of the health system financing model, aiming to integrate both individual and collective public health actions to enhance equity and efficiency. Second, it promotes a comprehensive approach, serving as a tool for financing other essential functions.

Access stage

The following three essential functions are operational in nature. They assess the capacities required to implement both individual and collective public health interventions at various levels. These functions pertain to access to high-quality, comprehensive health services, encompassing individual public health interventions delivered through the system. They include primary, secondary (screening), and tertiary (rehabilitation) care, as well as personal (individual) care. Additionally, they cover multisectoral and community-based interventions routinely managed in health facilities.

This phase also includes collective interventions aimed at reducing risk factors and fostering healthier environments, such as access to safe drinking water and roads, smoke-free environments, and front-of-pack nutrition labeling. Furthermore, it encompasses efforts to address the social determinants of health – such as poverty reduction and improved education – alongside broader health promotion initiatives.

- Equitable access to quality, comprehensive health services;
    - This function ensures access to high-quality, progressively expanded, and integrated public health services that align with population health needs, system capacity, and the national context. This is achieved through the organization and management of user-centered services, emphasizing family and community risk, life course considerations, and social determinants of health. A quality health service is one that meets the health needs of individuals, families, and communities based on ethical best practices and scientific evidence, contributing to equity and well-being. Special attention is given to diverse and vulnerable populations. Quality care in health service provision requires a person-, family-, and community-centered approach, with essential attributes such as safety, effectiveness, timeliness, efficiency, and equitable access. Achieving these attributes depends on the availability of services and their proper organization and management.

- Equitable access to interventions that promote health, reduce risk factors, and encourage healthy behaviors;
    - This function ensures access to all public health interventions aimed at minimizing exposure to risk factors and fostering healthier environments. It includes policies that prevent risk factors for non-communicable diseases, such as fiscal policies and regulations on marketing, labeling, and product promotion (e.g.,

tobacco and alcohol taxes). It also involves the promotion and protection of breastfeeding, physical activity, and smoke-free environments. Additionally, it includes policies to guarantee basic sanitation, safe transportation, vector and air pollution control, food and chemical safety, and measures for climate change adaptation and mitigation. Environmental health and worker protection are also integral. To effectively implement these interventions, it is crucial for health authorities to reclaim leadership in intersectoral partnerships – an area that was neglected with the dominance of the biomedical model.

- Management and promotion of interventions on the social determinants of health.
    - This function encompasses intersectoral initiatives aimed at addressing structural socioeconomic factors that impact health, many of which fall outside the direct control of the health sector. While the health system itself is a key determinant, other critical factors – such as education quality, labor market stability, workplace safety, and housing conditions – must be tackled through intersectoral collaboration. In fulfilling this function, health authorities play a crucial role as partners in the development and implementation of initiatives that address these broader determinants of health.

On April 14, 2021, amid the COVID-19 pandemic, the WHO and the United States Agency for International Development (USAID) organized a technical meeting to develop strategies for building resilient health systems. The discussion centered on strengthening primary health care (PHC) and essential public health functions while integrating health security, human rights, and disease-specific care.

The meeting's final report highlights critical gaps in current approaches to health security and health systems planning and evaluation, particularly regarding to governance and collaborative mechanisms that integrate services and society. Participants emphasized the lack of clearly defined roles as a major barrier to strengthening the service resilience, particularly in mobilizing emergency responses, PHC and community engagement. According to the report (World Health Organization, 2021), financial planning fragmentation, workforce challenges, infrastructure deficiencies, and the low reliability and slow processing of health surveillance data further perpetuate this situation. The report also underscores the need to systematize organizational learning through appropriate tools and structures for monitoring and evaluating investments in health system resilience.

Traditionally, actions have focused on individual care, which weakens responsiveness – an essential capability for resilience. There is a pressing need to increase attention to equity and the social determinants of health, which are central to essential health system functions, particularly in those with strong PHC components. Strengthening public health functions enhances the potential of health systems to perform resiliently. According to the WHO, this can be achieved through investments in networking, such as WHO Collaborating Centers, especially in countries with low PHC coverage.

The most successful countries in tackling the COVID-19 pandemic developed responses centered on the social determinants of health. Many established task forces involving multiple government ministries to ensure the effective translation of evidence into policies and practices that preserved health system capacity while protecting the population. These countries also made significant investments in strengthening public health functions alongside new technologies and vaccines, while actively engaging communities through integrated communication strategies. A study conducted at the University of Toronto, which examined the responses of 28 countries to the pandemic, underscores these findings (Haldane *et al.*, 2021).

Summary

In this chapter, we have seen that, in response to unexpected events such as recent epidemics and pandemics, the World Health Organization (WHO) and the Pan American Health Organization (PAHO) have defined a minimum set of essential functions that must be maintained in regular operation to ensure the performance of health systems. These well-established and widely disseminated essential functions have been reviewed with a focus on resilient capacities, as described in recent literature – such as response, anticipation, health surveillance, capacity monitoring, and absorptive capacity.

In the next chapter, we present an exercise to analyze health systems resilience based on the resonance between public health functions.

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Chapter 15

Modeling the Variability of Essential Public Health Functions

Understanding the couplings between essential functions through models such as FRAM facilitates the early detection of variabilities.

Resilience has been a widely discussed attribute among global health authorities since the COVID-19 pandemic. Official documents published by WHO and PAHO, containing recommendations for their Member States, strongly emphasize the importance of developing resilience in health systems, as new crises are expected in the coming years. These institutions recognize the need to build resilience on a daily basis, making preparedness for chronic events a decisive factor in strengthening health systems' readiness for acute, extraordinary situations.

In this chapter, we present a brief exercise using the Functional Resonance Analysis Method (FRAM) to examine the effects of variability on the behavior of health systems, based on PAHO's framework of essential public health functions. The document published by PAHO provides a detailed account of the recommended operation of these functions, serving as a valuable source of information for understanding the

Work-as-Imagined (WAI) of resilient health systems. Additionally, it includes descriptions of the general state of each function worldwide, which we use here to model FRAM instantiations that illustrate both positive and negative performance variabilities, as well as the resonance between functions.

Alongside PAHO's official document (Pan American Health Organization, 2020), we also base our analysis on the article published in the *Pan American Journal of Public Health*, from which the document originated.

The essential public health functions are designed to support three key pillars:

- Integrating ethical values into public health actions to address health inequalities and their root causes;
- Ensuring universal access to comprehensive public health services, both individual and population-based;
- Expanding the management role of health authorities through a collaborative implementation of public health functions.

Naturally, the development of these essential functions varies across the world. As a result, different factors influence their implementation, leading to variations in accuracy, timing, and scope.

To illustrate the importance of coordinating essential health functions, Figure 10 and Table 2 present a FRAM analysis of these functions during the COVID-19 pandemic in Brazil.

The function that generates the most outputs is "Develop and implement policies and promote legislation that protects the health of the population". This function is responsible for establishing rules and general guidelines for public health actions, as well as for strengthening priority programs and research institutions. It also defines quality parameters for healthcare services and the organization of networks. For health authorities to implement evidence-based policies effectively, a formal regulatory framework is essential – one that is guided by the overarching goal of advancing universal health access.

The "Developing and implementing policies [...]" function depends on accurately interpreting the factors influencing population health and health inequities to propose relevant guidelines and develop effective strategies. It must also consider the social determinants of health, both in the development process and during implementation. Effective planning should encompass all elements that impact the health sector, including human resources, health technologies, financial arrangements, specific programs, and both public and private actors. Additionally, this function is closely linked to the legislative branch, which must establish an agenda that upholds equitable access to health as a fundamental human right.

Effective public health policymaking also requires strengthening the analytical, operational, and policy capacities of health authorities. In terms of analytical capabilities, the ability to access and apply technical and scientific knowledge depends on having a sufficient number of skilled personnel with critical thinking competencies.

Progress and challenges vary widely when it comes to designing public policies and health-related laws. In general, public health policies aim to expand coverage and access to healthcare services, leverage knowledge and technologies to address local issues, and tackle specific behavioral, environmental, and social risk factors. Often aligned with national priorities, these policies have led to the prioritization of interventions targeting different types of health problems.

Despite the advances made, one of the main challenges remains the limited development of the technical and political capacities necessary to build an integrated and consensual vision for the strengthening and transformation of health systems. Although countries have trained staff in policy development – particularly in strategic planning and management, the drafting of legal instruments, and the prioritization of public health policies – these capacities and competencies are unevenly distributed across countries and within national and subnational levels.

There is also limited coordination between the legislative branch (mainly health commissions) and health authorities in the adoption and implementation of executive rules, laws, regulatory decrees, and regulations. Additionally, deficiencies persist in updating health priorities, understanding acquired obligations, ensuring consistency in the articulation of different interventions, and assessing their effects and implications. Relevant actors from civil society, the private sector, knowledge management, and the community do not always participate in policymaking processes.

A clear example of these challenges is Brazil during the COVID-19 pandemic, which coincided with a serious political and institutional crisis among the branches of government. As described in the report of the Parliamentary Commission of Inquiry (CPI), established in April 2021 to investigate the federal government's actions during the pandemic, several measures hindered local authorities in Brazilian states and municipalities from implementing pandemic response actions, such as establishing lockdowns and issuing social distancing rules (Brasil, 2021). As a result, the function *"Develop and implement policies [...]"* was severely impaired, with several of its outputs deteriorating in terms of timing, accuracy, and quality. Figure 9 highlights in a darker tone the negatively affected outputs of the function *"Develop and implement policies [...]"*, along with their downstream couplings, illustrating the resonance in functions that depend on these outputs.

With their leadership weakened, local health authorities struggled to enforce restrictions, and regulations regarding restrictive measures proved ineffective. According to the CPI's final report, health planning was overridden by the advice of a "parallel cabinet" – a far-right group of doctors, scientists, and politicians recruited by the Brazilian government – which promoted ineffective treatments, delayed vaccine acquisition, and ultimately disrupted the immunization campaign. The distorted and inaccurate strategic planning prevented the full development of broad health promotion actions, such as non-pharmaceutical measures of social distancing and hygiene, which were crucial to containing the spread of the disease. The negative variability in planning also led to disorderly allocation of physical and human resources, resulting in chaotic fund expenditure and putting health workers at risk, as evidenced by the high number of infections and deaths among frontline workers.

1*	Leadership from the health authorities
2*	Integrated network
3*	Health policies
4*	Research institutions
5*	Health surveillance regulation
6*	Strong PHC component
7*	Quality standards
8*	Strategic planning
9*	Health work legislation

Table 2: Figure 9 captions.
Source: The authors.

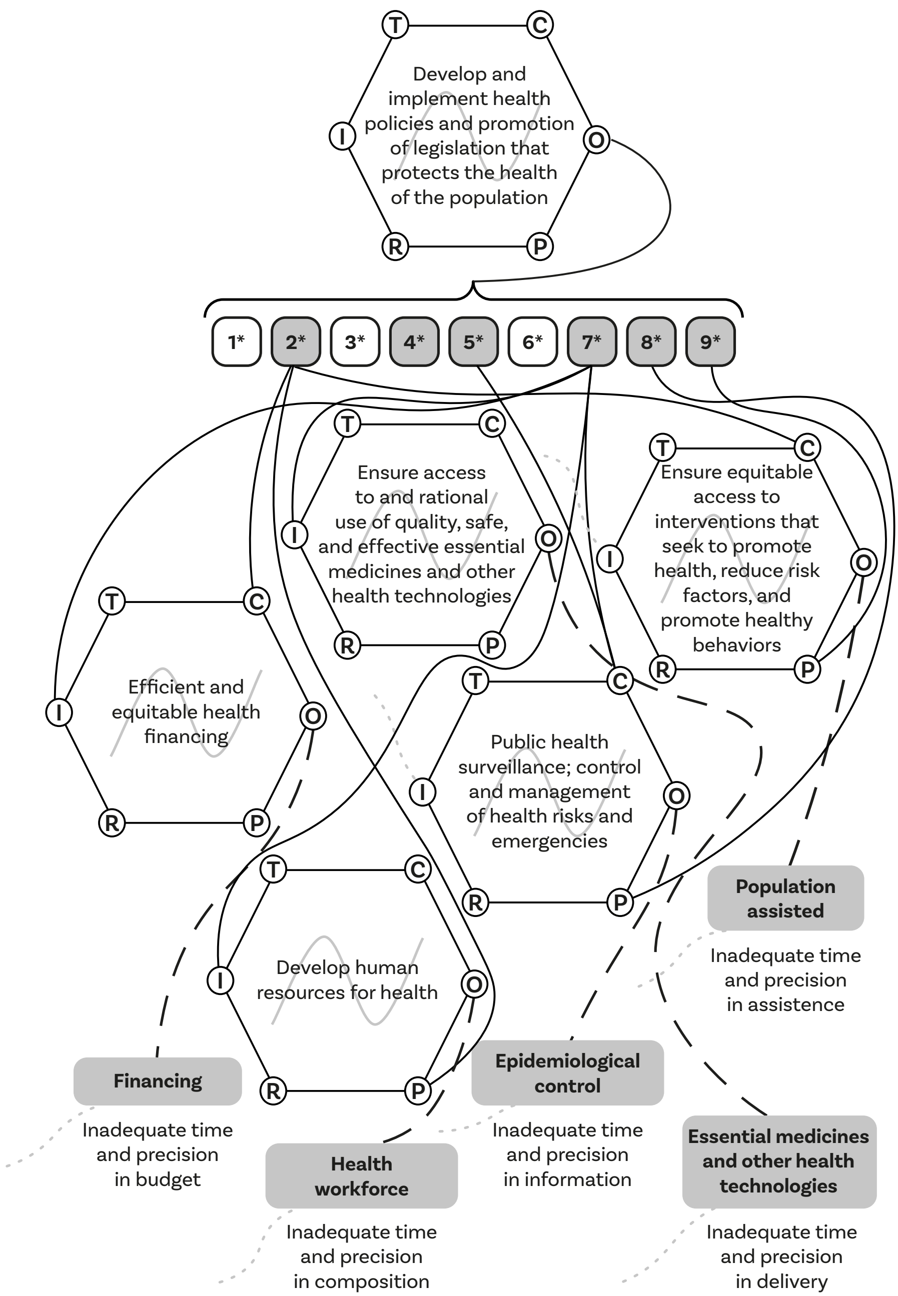

Figure 10: FRAM Model of the Essential Function of Health Policy Development during the COVID-19 Pandemic in Brazil.
Source: The authors.

The development of health policies must be based on evidence, and this aspect was one of the most affected by the federal government's performance during the pandemic, driven by its far-right political approach. As a result, this function experienced severe turbulence, impacting its outputs, as shown in Figure 9. The effects are particularly visible due to the importance of the "Develop and implement policies [...]" function, which generates multiple outputs for other downstream functions in the model (see Figure 9). At the same time, the functions that provide inputs for policy development were also heavily disrupted during the COVID-19 pandemic in Brazil, leading to upstream couplings that were far from reasonable.

The FRAM model in Figure 9 also highlights negative variations in the timely production of situational assessments, resulting in monitoring and evaluation gaps that compromise the quality and management of public policies. These gaps distort the scope, objectives, and accuracy of health policy guidelines, as well as adherence to laws, decrees, and normative instructions. Additionally, the scope and effectiveness of function outcomes are impaired when discrepancies arise in the functioning of monitoring and evaluation mechanisms.

According to PAHO's official document, almost all countries in the Americas lack a sufficient number of comprehensive monitoring and evaluation programs and projects. This deficiency compromises the use and dissemination of the information produced, the quality of statistical information systems, the legal framework, and, consequently, the reliability and security of data. Efforts have been primarily focused on software development and the adoption of isolated technological solutions, often at the expense of building capacities for the effective use of information in decision-making.

The evaluation of the population's health situation, produced by the function "Monitoring and evaluating health and well-being [...]", is essential not only for policy formulation but also for several other key functions. Variations in this output particularly impact the system's surveillance capabilities, represented by the function "Monitor, control and manage health risks and emergencies", with which it interacts by both providing and receiving information, mainly regarding data flow.

During the pandemic period in Brazil, there were multiple issues with the provision of disease-related information. Political interventions led to the shutdown of central government systems, resulting in data loss, arbitrary changes in disclosure times, and other disruptions. These issues escalated to the point where press outlets, together with municipalities, formed a consortium to independently research and consolidate information. Meanwhile, critical structures for monitoring population health conditions had already been suffering from a lack of investment. For example, the regional centers for strategic information on health surveillance (CIEVS), which played a crucial role during major events such as the 2014 FIFA World Cup and the 2016 Olympic and Paralympic Games, were severely impacted by economic and political crises.

Figure 11 details the functional resonance related to the monitoring function and its effects. Regardless of the challenges posed by the pandemic, the function of "Monitoring and evaluating health and well-being [...]" had already been facing serious obstacles, not only in Brazil but across all countries in the Americas. According to the PAHO document, even with advancements in monitoring and evaluation structures – such as those implemented in the SUS, particularly from the 2000s onward – most countries continue to struggle with strategic information management, data integration, and the formulation of comprehensive indicators. In particular, the development of leading indicators, which reflect system performance, remains a significant challenge. These structures are fundamental to making evidence-based decision-making more rational and effective.

Ensuring that information systems provide data for meaningful comparisons between population subgroups, as well as fostering the technical capacity to track, analyze, and communicate such information, are additional challenges for monitoring and evaluating equity in access to healthcare services and their impact on social determinants of health.

Many countries have made significant progress in various components of the epidemiological surveillance system, particularly regarding communicable diseases. This includes advancements in event monitoring – such as norms, protocols, and the articulation of strategies for systematic and timely data collection to support control interventions. A key aspect has been the increased use of population-based household surveys to assess the prevalence of health conditions and risk factors, including diabetes, hypertension, obesity, overweight, sedentary lifestyles, smoking, and dietary habits.

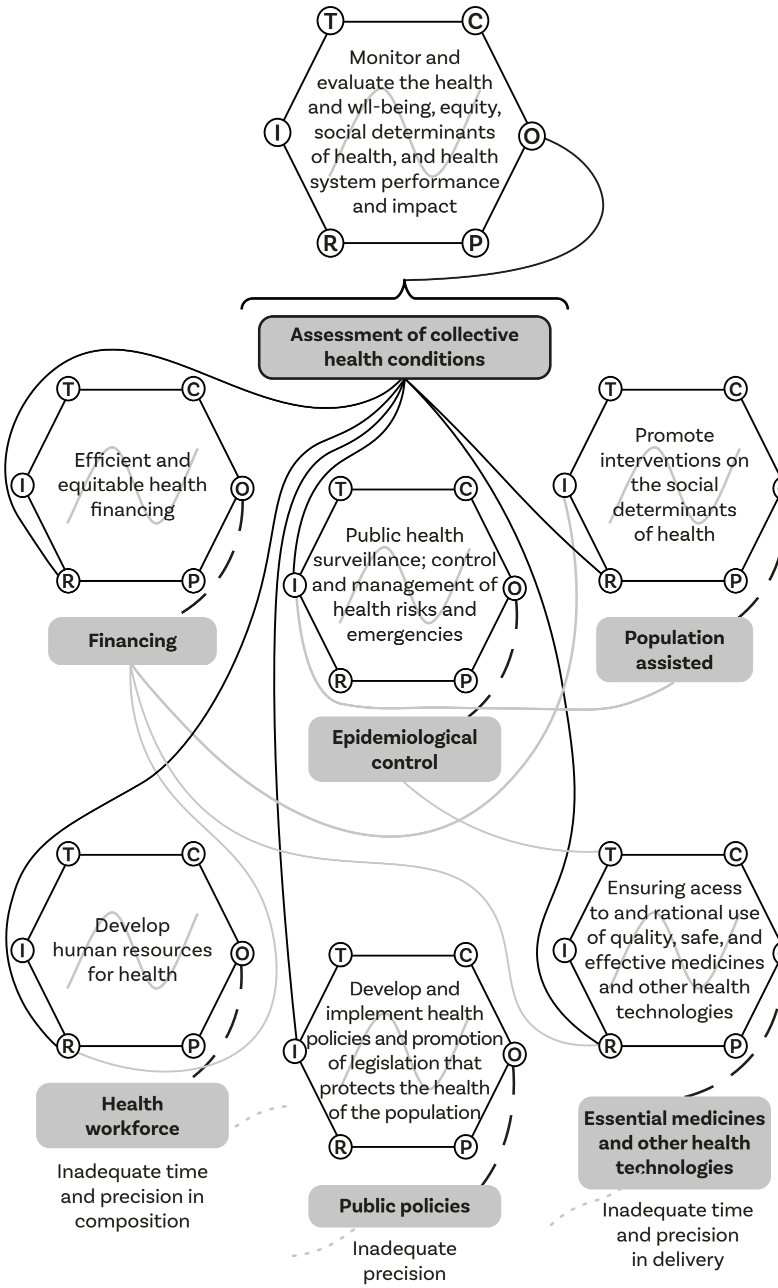

Figure 11: FRAM Model of the Essential Function of Monitoring Health Situations during the COVID-19 Pandemic in Brazil.
Source: The authors.

On the other hand, some countries lack household health surveys that include data on various dimensions of equity, such as economic status, urban or rural residence, and sex, among other factors. As a result, several functions that rely on situational assessments as a resource have experienced disruptions in their operation.

The simplified models presented in this section do not aim to exhaust all possible variations in the functioning of essential health system functions during the COVID-19 crisis in Brazil. Instead, these examples illustrate some contributions of the FRAM method to analyzing resonance between functions and highlight ways to strengthen resilient performance. In these examples, particular emphasis was placed on governance challenges, which, due to historical inequities in access and service availability, were key factors in the difficulties the SUS faced in responding to COVID-19.

It was demonstrated that the SUS, despite the turbulence in its governance arrangements during the pandemic, showed potential for resilient performance. Other aspects may be subject to further analysis in the future, such as the fragmentation of legal frameworks, limitations in the intersectoral coordination necessary for comprehensive care, the working conditions of health workers, the underfunding of programs, and the challenges in ensuring access for residents of vulnerable areas.

Summary

This chapter was dedicated to demonstrating how FRAM can be used to model the behavior of essential public health functions in response to highly disruptive situations – in this case, the COVID-19 pandemic in Brazil.

We consider resilience as the ability to adapt to the unexpected without disrupting the regular functioning of essential public health functions, analyzed here at a higher level of abstraction, based on the functions described by the Pan American Health Organization (PAHO). The key functions that must remain fully operational throughout the shock cycle require couplings with resonance spaces, where positive variabilities enable appropriate transformation and facilitate recovery once the event has passed.

Through a retrospective FRAM analysis, we modeled the normal functioning of essential public health functions in Brazil (*Work-as-Imagined* – WAI) and then created instantiations of the general model to better understand the actual behavior of some functions and their couplings during the critical moments of the pandemic (*Work-as-Done* – WAD). This process highlighted how variability influenced Brazil's response to COVID-19.

The modeling exercise presented in this chapter illustrates FRAM's usefulness in detecting – and predicting – how variabilities impact overall system behavior through blunt-end and sharp-end resonances. At the blunt end, we observed that actions taken by the federal government during the pandemic weakened local authorities' ability to formulate public policies to combat COVID-19, such as establishing lockdowns and issuing social distancing norms. This led to negative variabilities in the outcomes of the essential function *"Develop and implement policies [...]"*. At the sharp end, we identified negative variability in the supply of basic resources and preconditions, along with the demobilization of critical structures in Primary Health Care (PHC) and health surveillance. These issues were reflected in the resonances of the functions *"Monitor and evaluate health and well-being [...]"* and *"Monitor, control, and manage health risks and emergencies"*.

In the next chapter we will examine the structural foundations developed by health authorities for resilience in health systems, exploring the conceptual frameworks established by the Global Health Security Index (GHSI) and the World Health Organization (WHO) for designing health systems with resilient potential.

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Chapter 16

The Foundations for Coping with Crises and Disasters

The WHO proposes a basic set of dimensions, known as building blocks, through which the resilience of health systems should be developed.

The recent COVID-19 pandemic highlighted the need to understand health systems' operating conditions under unpredictable and variable circumstances. This arose from the limited effectiveness of certain evaluation models in predicting health systems' capacity to manage the pandemic. While these models – such as the Global Health Security Index (GHSI), which includes indicators of robustness and preparedness – implicitly reference important components, they do not directly address resilience itself (Cameron *et al.*, 2019).

Robustness, preparedness, and responsiveness are terms widely used in international literature on the institutional capacity of health systems. While often addressed tacitly, in a fragmented or limited manner, these concepts highlight the importance of certain components for developing the potential for resilient behavior in the face of future crises – whether new epidemics, disease outbreaks, natural or man-made disasters, rising demands for universal health access, mass migration, wars, or other challenges.

The discussion of health system resources involves two main aspects that, while related, have important distinctions. First are the material resources available – such as equipment, infrastructure, and financial assets; second are the human resources comprising the workforce. Material resources are commonly used to gauge a health system's capacity to effectively confront and respond to emergencies.

Intangible resources also play a role, including emergency preparedness time and clearly defined decision-making processes. Given the dynamic nature of community profiles, when resources are limited, unavailable, or difficult to mobilize, self-organization naturally emerges as people and organizations adapt their work based on the resources at hand.

The Global Health Security Index (GHSI), preparedness, and robustness

In 2019, Johns Hopkins University, in collaboration with the Nuclear Threat Initiative, published the Global Health Security Index (GHSI) (Cameron *et al.*, 2019). The GHSI aims to assess the institutional capacity of countries' health systems using a set of global health security indicators, focusing on preparedness and robustness.

In its 2019 edition, published before the COVID-19 pandemic, the GHSI listed a set of indicators organized into six dimensions:

- Prevention of the emergency of epidemics;
- Agility in the detection and information on epidemics with high-risk potential;
- Fast response to mitigate the spread of the epidemic;
- Accessibility of the health sector to assist the population;
- The country's commitment to international health standards, including financial terms;

- General environmental and biological risk conditions of the country.

In the 2019 evaluation of approximately 190 countries, the United States received the highest Global Health Security Index score (83.5 points), indicating the most robust health system globally. Based on this, then-President Donald Trump initially claimed that the pandemic's impact on American health would be minimal. However, as we now know, the U.S. became the global epicenter of COVID-19 from the outset, experiencing the highest number of fatalities.

In fact, not only the U.S. but also other countries with institutionally strong health systems performed poorly or only moderately in managing the pandemic. It is important to recognize that COVID-19 was an unexpected event – not because pandemics themselves are unforeseen – but due to its unprecedented disruptive power, which was initially underestimated. A key conclusion from the GHSI assessment is that it failed to accurately predict preparedness and strength – terms frequently referenced in the official report – overestimating some countries while underestimating others. Another conclusion is that preparedness and robustness, as defined by the GHSI, did not translate into resilience or effective capacity to manage COVID-19.

The state of preparedness (sometimes referred to as readiness) is generally defined as the capacity that enables effective response and recovery. Its significance for resilient performance is considerable, as a system that recovers well from a shock indicates a certain level of preparedness.

By enhancing their state of preparedness, organizations help reduce the risk and impact of catastrophic events. Specifically for public health, the WHO defines preparedness as "(...) the knowledge, capacities and organizational systems developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of probable, imminent or current emergencies” (WHO, 2019). As discussed later in Chapter 12, anticipation and response, along with learning and monitoring, are fundamental resilient capacities.

The predominantly biomedical and structural parameters used by the GHSI to assess preparedness were severely challenged by the pandemic’s unprecedented global disruptive potential. This was further exacerbated by the geopolitical landscape, which introduced extraordinary variability, causing many health systems to collapse or become unstable. For instance, denialism by populist leaders worldwide undermined national health system operations. Extreme opposition to key non-pharmacological measures – such as social distancing, mask usage, and later vaccine acquisition and immunization efforts – was encouraged. Even countries that managed the COVID-19 emergency relatively well faced difficulties in prioritizing healthcare services, often having to delay or suspend routine procedures like elective surgeries.

There is no doubt that the GHSI failed to accurately assess the preparedness of health systems, but this was not the only issue. In disruptive events like the COVID-19 pandemic, health systems are expected to demonstrate resilience – that is, to adapt effectively to the unexpected while simultaneously maintaining their routine functions.

The indicators in the GHSI reflect institutional capacity, focusing primarily on health system structures, but provide little insight into how these structures function under stress. Consequently, this indicator framework only partially captures preparedness, strength, and responsiveness – key aspects of resilience that are heavily influenced by how health systems operate during extraordinary disruptions.

Indeed, preparedness and robustness are typically associated with institutional capacity. However, COVID-19 revealed that these alone are poor predictors of health system performance in emergencies – as even the authors of the GHSI acknowledged in the 2021 edition (Bell *et al.*, 2021), released during the pandemic. Social, political, environmental, and cultural factors also shape health system behavior, making it unsurprising that an index like the GHSI, which mainly comprises structural indicators, struggles to predict how resources will be deployed, especially in acute crises.

The response of some countries, including Brazil, demonstrates that even strong resource mobilization capacity does not necessarily equate to resilience. When examining the relationship between citizens and public policy, factors such as government distrust, political climate, governance structures, and media influence must be considered. According to the GHSI authors, these elements are not the sole explanation but help clarify why some countries with high 2019 Index scores responded poorly to the pandemic.

As a measure of health security, the GHSI assigns the highest scores to countries with the greatest capacities to prevent and respond to epidemics and pandemics. Consequently, wealthier nations – with substantial investments in science and technology – tend to rank highest. While the GHSI identifies available resources, it cannot determine if or how a country will utilize these means to demonstrate resilient behavior. For example, the index does not predict whether health authorities will follow expert recommendations or effectively deploy available technologies.

On the other hand, the GHSI provides valuable insight into the tools countries possess and the risks they face in protecting their communities – analysis that is important for promoting resilient behavior. By maintaining a continuous focus on resilience, the capabilities identified through the GHSI must be cultivated daily, highlighting how they contribute to sustaining system stability and long-term readiness. For instance, resilient performance requires more than just having the resources to purchase sufficient rapid tests; it necessitates developing, over time, the capacity to mobilize the population for systematic testing.

The 2021 edition of the GHSI includes revisions, although it still assigns higher scores to wealthier countries – the United States remains in first place, for example. This does not diminish the importance of GHSI indicators for resilience. On the contrary, preparedness, robustness, structures, and resources remain critical factors for resilient performance.

The updated GHSI identifies additional factors influencing countries' performance, including testing capacity, contact tracing, maintenance of laboratory facilities during emergencies, and implementation of non-pharmaceutical interventions. It is important to note that the GHSI is based on publicly available information. Despite extensive public scrutiny of governments' pandemic responses, data on governance are limited and complex to interpret. Comprehensive qualitative analysis of diverse data sources is necessary, along with models capable of integrating subjective and objective elements into a unified index like the GHSI.

WHO's building blocks for resilient health systems

The WHO framework for building climate-resilient health systems was launched in 2015 to guide Member States – particularly the health sector – in systematically and effectively addressing the increasing challenges posed by climate variability and change. The WHO's proposal emphasizes developing the capacity of health systems to:

- Understand, monitor, anticipate, communicate and prepare for changes in climate-related health risks;
- Prevent, respond, manage and deal with uncertainty, adversity and stress;
- Adapt operations and health functions to deal with risk change;

- Recover from crises and setbacks effectively and with reduced dependence on external support;
- Learn from experience and improve the system's capacity for the future.

The similarities with the four resilient abilities proposed by Erik Hollnagel in Chapter 13 are quite evident, even if not explicitly acknowledged by the framework's authors. From these implications, six main axes – referred to as "building blocks" – are defined, through which the WHO suggests health systems can be designed to inherently possess resilient performance.

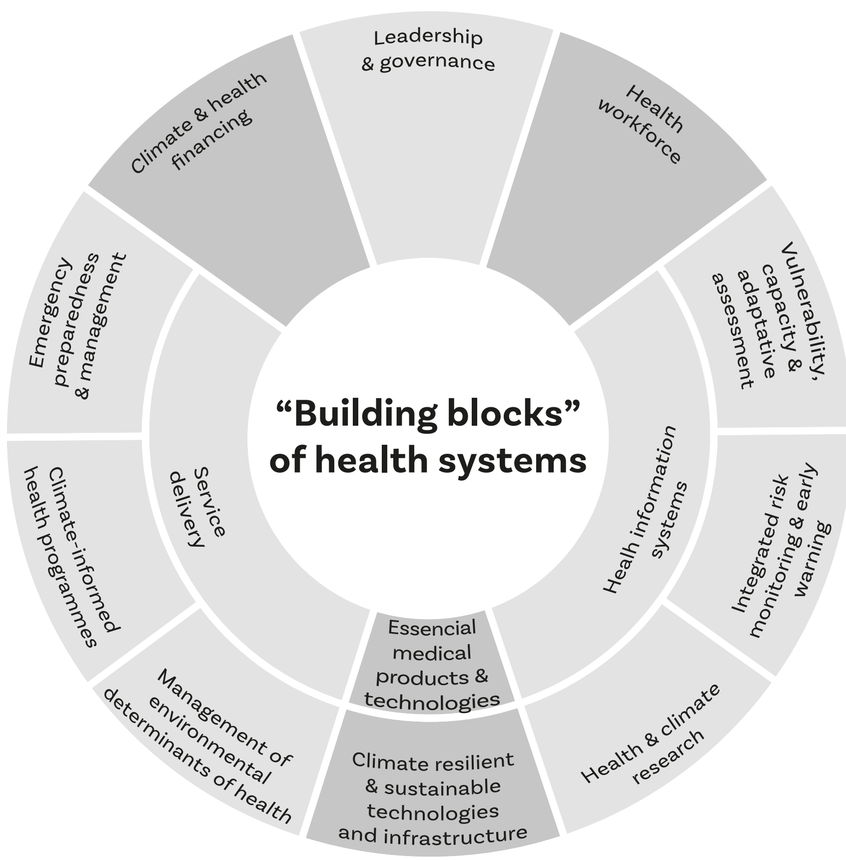

Figure 12: Building blocks for resilient health systems.
Source: Adapted from World Health Organization (2017b). Authors' translation.

The six "building blocks" – leadership and governance; health workforce; health information systems; essential medical products and technologies; service delivery; and financing – serve as foundational elements for enhancing overall health system resilience to climate change and strengthening existing capacities. The operational structure encompasses all six building blocks through ten components (illustrated in the outer ring of Figure 12), with some blocks – such as service delivery and health information systems – addressed by multiple components.

To protect population health, the health sector must develop these ten components of resilience in collaboration with sectors directly influencing health – such as water, energy, and agriculture – and, importantly, secure community engagement in this effort.

- **Leadership and Governance:**
  - The objectives of this component are: (i) to establish specific responsibilities and accountability mechanisms related to climate change and health within the Ministry of Health; (ii) to incorporate considerations of climate variability and change into key health policies and programs; and (iii) to strengthen cross-sector collaboration and maximize synergies, ensuring decisions in other sectors protect and promote health.

- **Health workforce:**
  - The objectives of this component are to ensure that: (i) a sufficient number of health professionals with the necessary technical capacity are available to address health risks posed by climate variability and change; (ii) resources, information, knowledge, and processes

used by the health sector are efficiently and effectively applied to manage additional risks; and (iii) awareness of the relationship between climate change and health promotion is raised among key target audiences, including policymakers, senior staff, media, and communities.

- **Vulnerability, capacity and adaptation assessment:**
  - The objectives of this component are: (i) to develop a thorough understanding of the key health risks posed by climate variability and change, and to identify the country's most vulnerable populations; (ii) to establish a basic registry of capacities and gaps within the health system to address climate change challenges; and (iii) to identify adaptation options – including their comparative advantages, potential costs, and efficiencies – for consideration by health system decision-makers.

- **Risk monitoring and early warning:**
  - Integrated risk monitoring involves using epidemiological surveillance tools alongside direct and remote sensing technologies to monitor environmental determinants of health – such as water and air quality, ambient temperature and humidity fluctuations, and extreme weather events. The goal of this component is to employ integrated disease surveillance and monitor a broad array of signals related to health risks and early warning systems, enabling faster detection of changing conditions and anticipation of weather-related outbreaks and emergencies.

- **Health and climate research:**
    - Building climate resilience requires both basic and applied research to reduce uncertainty about local impacts, gain insights into local solutions and capacities, and provide evidence to inform decision-making. The objectives of this component are: (i) to develop and agree upon a multidisciplinary national research agenda on climate change and health; (ii) to support the enhancement of research capacity; and (iii) to disseminate research findings to policymakers to guide action.

- **Sustainable, climate-resilient technologies and infrastructure:**
    - The objectives of this component are to ensure that: (i) climate risks are systematically integrated into decisions regarding technologies, products, and procedures for health infrastructure and services; (ii) new technologies, processes, and products are selected and promoted with climate resilience in mind; and (iii) the sustainability of health operations is enhanced to build climate resilience and support long-term sustainability. This component also addresses the climate resilience of essential services – such as water, sanitation, and electricity supply – which can be disrupted during extreme weather events, thereby affecting the efficacy of certain medical products and vaccines.

- **Management of environmental determinants of health:**
    - Climate change threatens health by impacting environmental determinants such as air and water quality,

water availability, food and nutrition security, housing, and waste management. The overall objective of this component is to strengthen the health system's role in identifying and managing these determinants through public health prevention programs in collaboration with other sectors that influence health – such as industry, energy, transport, water, agriculture, and municipal administrations. The specific objectives are: (i) to ensure joint monitoring of climate-sensitive environmental risks based on evidence; (ii) to promote the creation, review, and enforcement of regulatory policies protecting populations from these risks; and (iii) to improve coordinated management of environmental health determinants, with clearly defined roles and responsibilities across sectors.

- **Climate-based health programs:**
    - Variability and climate change will affect vector-borne and waterborne diseases, while extreme weather events will cause injuries, mental and occupational health issues, and damage health facilities. Therefore, the broader objective of this component is to ensure that health policy, programming, and operations are increasingly designed and implemented with consideration of both current climate variability and future changes. Aligned with the Framework's goals for building climate-resilient health systems in the Southeast Asia Region (2017–2022), health services can enhance resilience by using information on current and projected climate conditions to identify capacity gaps

and guide policy, strategic investment, and planning decisions. Additionally, weather-based programming will continuously adapt service delivery based on new information to address emerging climate risks.

- **Emergency preparedness and management:**
    - Preparedness plans, emergency systems, and community-based disaster and emergency management are essential for building climate resilience. Health systems should therefore aim to manage public health risks holistically, emphasizing preparedness alongside the traditional focus on emergency response. The objectives of this component are to ensure that: (i) emergency and disaster risk management protocols and policies incorporate current and projected climate conditions; (ii) the health system's capacity to manage risks is strengthened to reduce global vulnerability and exposure, while effectively addressing residual risks and uncertainties; and (iii) communities are empowered to prevent and respond effectively to health risks posed by extreme weather events.

- **Financing of environmental and health actions:**
    - The purpose of this component is to identify needs and propose, as well as monitor, additional funding sources required to build the resilience of the health system to climate change. Examples of necessary funding include expanding geographic or seasonal coverage, increasing population reach for health surveillance programs, and retrofitting health facilities to withstand extreme weather events.

According to the WHO, human resources and social infrastructure are vital assets for building resilience. Developing people through training, experience, and specialized knowledge is essential. Training should emphasize critical emergency management skills – such as communication and collaboration – while also incorporating successful day-to-day local experiences that contribute to system stability. Additionally, the workforce must be aligned with the characteristics of the community it serves.

When unexpected events occur or circumstances shift during routine operations, the workforce must be prepared and qualified to adapt their response strategies. Diversity among personnel is therefore a valuable asset for resilient performance and contributes to the system's complexity. Workers require adequate support from management layers to develop the adaptive skills needed – especially since teams are often directly impacted by emergencies and their consequences. Additionally, workforce contingency and redundancy are necessary to enhance adaptive capacity.

Two recent studies published in prominent journals applied the WHO framework to analyze health system resilience during the COVID-19 pandemic. The first, published in Nature Medicine, examined the responses of 28 countries (Haldane *et al.*, 2021). A research team from the University of Toronto adapted the WHO's Building Blocks framework, referring to their version as the Determinants of Resilience.

Through an extensive retrospective analysis of data from the 28 countries' pandemic responses, the researchers identified key areas of resilience and fragility within health systems. Among numerous commonalities in the measures implemented, the study found that the most successful health systems demonstrated four core capacities:

- Address the health and well-being of the population holistically, that is, considering physical, social and economic well-being;
- Adapt the health system internally and externally to meet the needs of communities;
- Preserve functions and resources inside and outside the health system to maintain the most complex routine and care, whether related to the pandemic or not;
- Reduce vulnerabilities to sequelae of serious events in communities, both in terms of health and well-being and financially, individually and collectively.

Alongside these four capacities, some of the most successful countries in managing COVID-19 also demonstrated the ability to continuously learn, monitor, and adjust their performance in response to emerging evidence and evolving epidemiological conditions – aligning closely with the resilient abilities proposed by Erik Hollnagel (see the beginning of this chapter). These countries further showed capacity to mobilize additional hospital beds, establish field hospitals or repurpose existing facilities, and expand the workforce through redeployment and recruitment.

The study by Haldane *et al.* (2021) reveals that, overall, governments in the countries with the best outcomes established multi-ministerial task forces, invested in research, development, and supply production, implemented evidence-based policies and practices, aimed to preserve health system capacity, and worked to reduce vulnerability by providing financial and social support to the most vulnerable families.

Other specific measures included widespread testing and contact tracing in partnership with communities, ensuring that public health interventions reach all groups – particularly non-pharmacological measures such as mask-wearing and social distancing. Essential health system functions were preserved and reinforced, maintaining the delivery of services unrelated to COVID-19, especially programs at the primary health care (PHC) level.

The second study was conducted collaboratively by researchers from the Getúlio Vargas Foundation (FGV), the University of São Paulo (USP), Harvard University, and the Real e Benemérita Associação Portuguesa de Beneficência (Bigoni *et al.*, 2022). Published in The Lancet Regional Health – Americas, the research reveals that Brazil's SUS response contrasted with that of most countries that effectively managed the pandemic, despite the SUS possessing capacities conducive to resilience – demonstrated in previous outbreaks such as Dengue, Zika, and Yellow Fever. In those instances, strong collaboration existed among the three government levels – federal, state, and municipal – as well as coordinated epidemiological surveillance, primary health care (PHC), and widespread emergency vaccination campaigns. Additionally, comprehensive government-led awareness initiatives were implemented.

The findings of Bigoni *et al.* (2022) indicate that a lack of coordination hindered communication among government authorities responsible for pandemic response, negatively impacting critical areas such as oxygen supply, personal protective equipment (PPE), mechanical ventilators, and other essential resources. Consequently, there was no coordinated increase in funding, workforce, or infrastructure necessary for patient diagnosis and screening. Furthermore, routine services of medium and high complexity – such as oncological, neurological, and cardiac surgeries – experienced significant interruptions, particularly in more vulnerable states.

The WHO framework recognizes that the constituent elements of health systems and the six building blocks of resilience rely on the political capital available to health authorities to mobilize resources supporting resilient performance. Conversely, this political dependence drives structural transformations over time. Given that health systems are inherently complex and adaptive, resilience must be viewed as a capacity to be developed rather than a fixed attribute.

As discussed in Chapter 4, strengthening health system structures does not guarantee improved system behavior during unexpected crises. Factors more closely associated with resilient crisis responses include the relationships, shared goals, and collaboration among actors – particularly users and service providers within communities. For the WHO framework to effectively promote resilience, it is essential to recognize that these elements and their interconnections are fundamental both during crises and in routine service delivery, and they must be integrated into health system design. Practically, this means that building resilience requires understanding health system components as interconnected elements rather than isolated aspects, a nuance sometimes overlooked in interpretations of the WHO model.

Achieving ambitious health goals, such as those outlined in the SDGs, requires strong, functional, and inclusive health systems. The WHO's "building blocks" highlight only the essential elements, necessitating additional efforts and investments to ensure universal access and coverage that address the broad determinants of health. While the six building blocks serve as a valuable starting point for health managers and authorities, the most critical factors are the provision of comprehensive and equitable services, along with strategies, investments, and political will tailored to the specific needs of populations.

According to Savigny and Adam (2009), in the WHO-edited book Systems Thinking for Health Systems Strengthening, the proposed framework maps six essential groups of necessary inputs but is too static to fully capture the complexity of any health system and should be tailored to the specific context of application. While the "building blocks" serve as useful defining elements, they remain limited in describing the essential and interrelated functions of a system. Consequently, they should not be viewed as a definitive model for implementing health systems resilient to every situation or reality.

Summary

In this chapter, we presented the Global Health Security Index (GHSI) and the World Health Organization (WHO) frameworks for building health systems capable of managing crises and disasters.

The GHSI, which is based on system structure and capacity indicators, faced criticism due to discrepancies between its predictions and the actual performance of the United States health system during COVID-19.

The WHO's framework initially focused on health issues related to climate change impacts. Rooted in essential public health functions, it outlines a series of actions and inputs vital for resilience that should be integrated into health system design. Although heavily influenced by resilience concepts from natural disaster management, the framework proposes general elements applicable to resilience in any crisis.

In the next chapter, we explore the evolution of this framework by the European Commission, which evaluates the responses of various

Member States to COVID-19. This analysis defines strategies for managing all types of crises and disasters, promoting the adoption of new public health functions and attributes to strengthen system resilience throughout the cycle of shock.

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Chapter 17

Strategies Throughout the Cycle of Shock

As shocks evolve, the adoption of flexible strategies enhances resilient potential, as demonstrated by the experiences of several European Union countries in managing COVID-19.

In the mid-2010s – prior to the COVID-19 pandemic – the Council of the European Union invited Member States to establish a working group in collaboration with the OECD, the WHO Regional Office for Europe, and the European Commission's State of Health in the EU (SoHEU). The group's aim was to promote experience exchange, identify tools and methodologies, and define criteria and priority areas for assessing health system performance.

The European Union working group on health systems performance evaluation began its activities in 2014. Between 2019 and 2020, it concentrated on identifying tools and methods to evaluate health system resilience. This effort led to a conceptualization of resilience applied to health systems, emphasizing its potential as an independent dimension in performance assessment, as discussed in the preamble to Part I. Additionally, the working group proposed a conceptual framework to support the development of methods for measuring and evaluating health resilience across European Union countries.

This approach organizes essential health system functions based on their activation potential within the shock cycle – the progression of a disruptive event within the system. According to the authors, linking resilience to the shock cycle highlights various stages of opportunity, and resilient health systems are those capable of effectively managing each stage, whether predictable or not. Such systems must rapidly identify and absorb shocks, adapting as needed to maintain care quality during crises. After the shock subsides, they should be able to recognize and address any negative impacts on their performance (European Commission, 2022).

The stages in the cycle of shock

The nature of the strategic response depends on the type and severity of the shock, as well as the stage within the shock cycle the system is experiencing. Considering this can help identify opportunities to enhance resilience. Four stages can be distinguished within a shock cycle:

- **Preparation:**
    - This stage relates to how open or vulnerable a system is to shocks. It offers the greatest opportunity for action and is a crucial time to strengthen health systems and consolidate existing resources. Generally, the better a health system performs, the more resilient it tends to be. However, this is not always the case, as systems with varying weaknesses can still prepare effectively for specific shocks. At this stage, the system must prepare for potential shocks and identify optimal responses by scanning the horizon to anticipate threats, recognizing that different threats may demand different actions.

- **Start and alert:**
    - At this stage, the focus is on the timely detection of the onset and type of shock, which requires robust and comprehensive surveillance alongside early warning systems. Clearly, the sooner a shock is recognized, the faster and more effective the response can be. For example, in infectious disease outbreaks, early warning systems detect sentinel cases or deviations from historical trends, prompting epidemiological investigations to determine if intervention is necessary. Effective surveillance depends on the ability to collect timely, complete, consistent, and high-quality data across a broad range of indicators.

- **Impact and management:**
    - As a shock impacts the health system and society, the response falls within the traditional resilience domains of absorption, adaptation, and transformation. Absorption does not mean the system incorporates the shock, but rather how it prevents severe resource imbalance by mobilizing additional resources, whether from reserves or contingency plans. For instance, counter-cyclical health financing exemplifies good governance and effective protection of health system funds during economic shocks. Adaptation involves managing increased demand, reducing supply, or both – making the system more efficient by "doing more with less" or reallocating resources. This often entails adapting service delivery within the system. When adaptation proves

insufficient or all easy efficiencies are exhausted, the system may require more radical change (transformation) to address the shock's impact, potentially necessitating a rethink of health system policies. This transformation can sometimes compete with adaptation efforts, especially when governance capacity is limited.

- **Recovery and learning:**
    - This stage marks the overcoming of the shock and a return to some form of normalcy. Although the immediate imbalance caused by the shock has ended, significant changes – legacies of the shock – may persist, resulting in a "new normal" that differs from the previous state. Shocks often cause shifts in demand and supply and leave lasting effects on communities, institutions, and culture, alongside deliberate adaptations. These legacies can be positive or negative; for example, employees may be demotivated, staffing capacity reduced, or families face financial hardship. Recognizing these legacy factors and assessing their ongoing impact on system performance is crucial, even after the shock has passed.

In Figure 13, the essential functions of health systems are linked to the stages of the shock cycle, although these relationships are rarely clear-cut, with overlaps in stages and strategies. While such overlaps can be beneficial at any time, the European Commission's model assigns specific functions to each phase of the shock cycle on an ad hoc basis, according to their relevance at that moment.

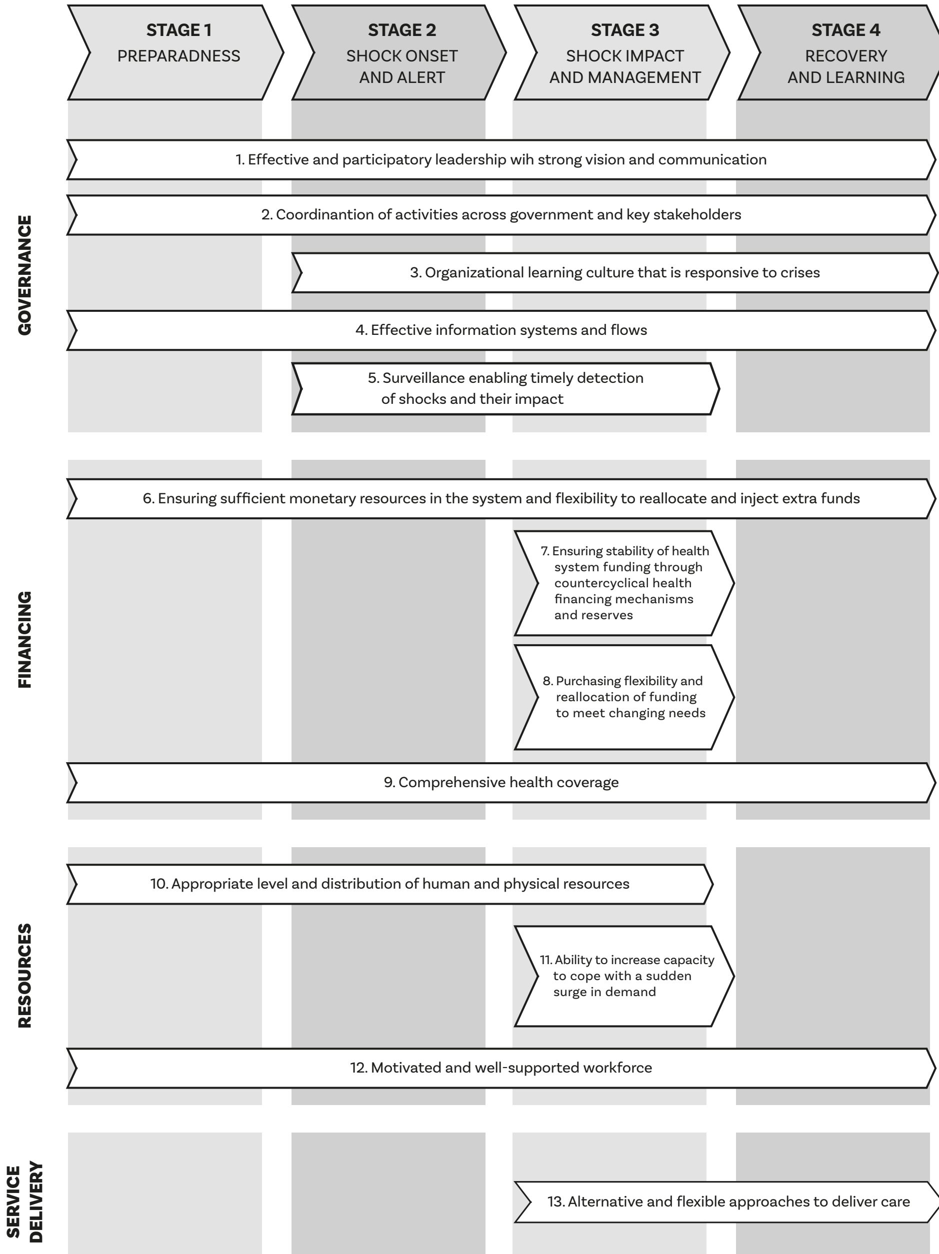

Figure 13: Resilient strategies by function and stage in the cycle of shock.
Source: Adapted from Thomas *et al.* (2020).

- **Governance:**
    - Effective and participatory leadership with a clear vision and strong communication is vital for coordinating diverse stakeholders. Such leadership must demonstrate the health system's key role in effectively preventing, detecting, and addressing public health threats, benefiting society broadly – including the economy, transport, tourism, and trade sectors. A crucial attribute of effective leadership is the ability to advocate for strengthening the health system to enhance resilience, even when persuading decision-makers about the importance of prevention and preparedness is challenging. International Health Regulations provide a legal framework for signatory countries to embed resilience capacities within leadership roles during health emergencies.
    - Coordination of activities among government and key actors involves ensuring effective collaboration across sectors, different levels of public administration, and between governmental and non-governmental stakeholders. This may include establishing or strengthening cooperation channels with other governments and international institutions. Coordination encompasses planning for specific shocks, allocating resources to these plans, and conducting drills or simulations to test the system's capacity to respond effectively to acute shocks like epidemics or natural disasters. Emergency management plans for disease outbreaks and contingency plans for supply shortages involving multiple stakeholders can be highly

valuable but must be consistently followed and fully implemented. Fragmented actions in other phases can lead to delays in critical responses. For instance, during shocks, when the government cannot reach all health services directly, effective collaboration with non-governmental actors becomes essential.

- An organizational learning culture that responds to crises is crucial for building resilience and enabling timely use of evidence. Learning from both successes and failures ensures more effective responses during shocks and in future events. This commitment to learning is important throughout the entire shock cycle, not only in its final stage, which addresses legacy issues and reflection on experience.
- Effective information systems and flows are central to decision-making in any policy process. Systems that facilitate the sharing of critical information among stakeholders are essential and should be incorporated into planning during policy development. While vigilance is especially crucial in the early stages of a shock and throughout its management, it fundamentally depends on generating effective information flows that enable decision-makers and managers to respond swiftly and select appropriate interventions. Conversely, poor information systems and fragmented communication can undermine effective preparedness and timely shock management.

Surveillance systems must enable timely detection of shocks and their impacts by quickly detecting, verifying, and tracking events in real time or as soon as possible. It is essential that data reaches all relevant stakeholders and can be rapidly converted into actionable information for decision-making. This requires strong integration of surveillance components, including alert systems, clinical and laboratory services, research findings, resource data, evidence synthesis, and communication efforts.

- **Financing:**
    - Ensuring sufficient financial resources and flexibility to reallocate and inject additional funds is a key aspect of resilience. It is essential that adequate funding is available for the health system and that, during a crisis, these resources can be rapidly mobilized as needed. To maintain resilience in a crisis, funds must be quickly directed to where they are most required. Insufficient resources can prevent those in need from accessing services or shift costs to households through out-of-pocket payments. A resilient response might involve the government temporarily increasing healthcare funding and reducing user fees to ensure continued patient access to services.
    - Ensuring the stability of health system financing through countercyclical mechanisms and reserves is critical. In most countries, health systems are primarily funded by taxation and social contributions. Shocks often affect these revenue sources, impacting households contributing via taxes and fees, consumption patterns, businesses, and more. To maintain resilience, financing mechanisms must be designed to withstand such shocks (a challenging task), including building reserves within the health system or implementing automatic stabilizers that activate during shocks. Although population aging is not a shock per se, gradual demographic shifts can

destabilize revenue generation as the proportion of older adults outside the workforce grows.

- Purchase flexibility and the ability to reallocate financing to meet changing needs are essential during shocks. Demand for certain types of care may shift significantly, requiring resource redirection. Additionally, purchasing can be used to incentivize specific provider behaviors. For example, a crisis might necessitate increased purchases from private providers who typically do not participate in publicly funded health systems. However, engaging these providers can be challenging without existing mechanisms or the capacity to overcome regulatory barriers.
- Comprehensive health coverage: needless to say, a comprehensive, evidence-based package of the availability of services and resources, properly organized and distributed, offers better chances for health activities to be maintained even in the presence of shocks. In countries where health services are not covered or require high individual payments, people may face barriers in accessing care. This is especially true for vulnerable groups already excluded from the statutory health system, who may be more severely affected by a crisis. If there is no comprehensive set of services available, it will be difficult to quickly deploy the new services to meet the needs.

- **Resources:**
  - Adequate level and distribution of human and physical resources: general preparation for any shock may require ensuring that the resources of the health

system – both human and physical – are sufficient and well distributed. In terms of workforce, this means adequate levels of staffing such as doctors, nurses and other healthcare professionals. For infrastructure, it is not enough to have enough hospitals and beds. It is necessary that the services (emergency, primary and specialized care) are provided in the appropriate environment. In a crisis, having sufficient and properly distributed resources can buy time to increase capacity and allow for the necessary flexibility. In contrast, going into a clash with staff and resource shortages, or routinely operating at peak capacity, can exacerbate existing gaps in access to care and undermine the response.

- Ability to handle a sudden increase in demand: a degree of excess built into or "surge capacity" in the system allows for an effective response to a rapid increase in demand. However, there is also a view that oversized preparedness – called "over-optimization" – mobilized to address a specific disaster can increase the system's vulnerability to other unforeseen shocks and stresses unless it results in the overall strengthening of the health system from the start. If the required resources are in place or there is a mechanism in place to deploy them quickly, the system is already equipped to handle a sudden increase in demand.

- Motivated and well-supported workforce: healthcare workers on the front lines of responding to certain types of shock are among the groups most directly affected, especially in outbreaks of communicable diseases. A long duration of shock can undermine motivation if there is not very careful management and support. A robust, flexible, and motivated workforce is a critical element of preparedness that enables adaptability in response to any type of shock. Employees motivated and supported by human resource management are more likely to temporarily take on extra burdens to see the system through a transition. In situations where health professionals need to be relocated to meet increased demand, long-term planning and training for workforce development is crucial.

- **Service:**
  - Alternative and flexible approaches to service delivery are crucial during shocks, which disrupt the balance between supply and demand and require improved resource management to meet new needs. Responses should enhance efficiency, such as shifting care to lower-cost settings or adjusting the provider mix. Shocks may also affect the efficiency of specific services, making flexibility essential. Well-defined care pathways support coordination and continuity, but alternative pathways may need to be activated if normal routes are interrupted. This flexibility enables the system to overcome unexpected barriers temporarily, allowing time for adjustment while maintaining essential care access. In severe or prolonged crises, after implementing simpler reforms, policymakers may need to pursue more complex changes, potentially with additional investments, to enhance efficiency, quality, and long-term access.

> During the recent economic crisis, several countries enacted reforms shifting care away from hospitals and increasing reliance on health technology assessments to guide service delivery changes.

This multifaceted view of resilience provides a foundation for identifying relevant strategies and assessment areas. The proponents emphasize the shock management phase, which primarily occurs at the sharp end, where connections between existing structures and processes are most visible. However, it is crucial not to overlook important resilience or fragility factors that arise at the blunt end. The COVID-19 pandemic has underscored the need for comprehensive actions that cultivate resilience daily, even as policymaker attention in recent years has increasingly focused on preparing health systems to manage both acute and chronic stresses.

The countries of the European Union provide a clear example of the impacts of events such as climate change, mass migration, demographic and epidemiological transitions, and other common regional threats. Beyond the model discussed in this chapter, European countries' responses to the COVID-19 pandemic involved deploying various instruments and establishing new coordinated preparedness and response mechanisms, including more flexible financing to support Member States' recovery. These efforts have led to several long-term initiatives with potentially significant effects on health systems.

Moreover, by substantially increasing budgets and expanding the scope of existing instruments, the European Commission established the Health Emergency Preparedness and Response Authority (HERA) to coordinate public health emergency preparedness, planning, and response mechanisms. HERA is responsible for defining rules for a flexible, more integrated surveillance system with enhanced risk assessment capabilities and targeted actions.

Finally, the proposal includes developing a binding pandemic preparedness plan among all Member States, empowering the Commission to recognize and declare future health emergencies in the region, thereby triggering common measures and specific response mechanisms. The scope of functions extends from identifying promising new medicines and technologies to supporting the development and expansion of the health industry within the European Union, reinforcing the multisectoral nature of public health. It also involves monitoring and evaluating emerging biomedical issues. Additionally, as a consequence of the pandemic, Member States have developed National Recovery and Resilience Plans, many of which allocate additional resources to strengthen primary health care programs by creating more health facilities focused on primary care.

A notable example of the European Commission's shock cycle strategy model was demonstrated during COVID-19, when twenty strategies were developed to foster a resilient response to the pandemic (Sagan *et al.*, 2021). This experience underscored the critical role of governance in resilient performance – not only ensuring that financing, resource generation, and service delivery functioned effectively but also that these elements were harmoniously coordinated.

The Commission's report also highlights how the experiences of European Union countries offer valuable insights into strengthening the resilience potential of regional health systems beyond merely enhancing their attributes and structures. Fundamentally, the report emphasizes the importance of political will to prioritize health sector investments, robust surveillance and monitoring, a well-trained and equipped workforce, and the central role of primary health care

(PHC) in resilient performance. Additionally, it stresses the need to address social determinants of health decisively, especially given recent challenges such as refugee crises, epidemiological transitions, wars, and other humanitarian emergencies affecting countries in the region.

The European experience also underscores the importance of intersectoral collaboration for resilience in public health, as much of the pandemic response required coordination beyond the health system alone. This highlights the necessity for effective articulation and governance among different sectors of government to ensure the quality of care is maintained even during major crises.

The European Commission's strategies

Next, we present the twenty strategies for health system resilience outlined by the European Commission throughout the COVID-19 shock cycle. The brief descriptions of each strategy have been extracted and adapted from the official 2021 document published during the pandemic's critical period (Sagan *et al.*, 2021).

1. Guide the response through effective political leadership

This strategy involves mobilizing broad political governance arrangements based on credible leadership. Health authorities must coordinate with leaders from various sectors and spearhead unified actions within the health sector. The following steps should be undertaken:

- Promote responsiveness, resourcefulness and learning capacity in leaders and organizations, including through the rational use of health data;
- Assess the strengths and vulnerabilities of the political system,

map incentives, allocate resources and distribute powers;

- Strengthen communication within and between governments regarding the functioning of health systems;
- Encourage consensus-building efforts, such as inter-parliamentary committees;
- Promote good governance, emphasizing transparency, accountability, participation, integrity and political capacity.

2. Mobilize a clear and timely response strategy to COVID-19

This entails developing coherent response strategies in a timely manner, resolving conflicts between options, and effectively deciding and implementing health and economic solutions based on priorities grounded in the following values:

- Establish and update emergency response plans;
- Have the possibility to introduce emergency legislation at national level;
- Define limited deadlines for the duration of the special powers granted to the authorities to deal with the emergency, guaranteeing civil liberties;
- Use appropriate tools and defined pathways that consider policy interventions in light of the national context, social interests and stakeholders, making policy outcomes acceptable and implementable;
- Formally mobilize scientific knowledge and expertise to fill gaps in empirical evidence-based policymaking;
- Communicate with the population in a coherent and transparent manner.

3. Strengthen monitoring, surveillance and early warning

It is part of the competence of the health system and is essential for the execution of a strategy of anticipation of responses and accountability. Suggested measures are:

- Develop strong surveillance and monitoring systems for emerging diseases;
- Monitor the reach of essential services and the access of vulnerable groups;
- Adopt digital disease detection tools and coordinate mechanisms to support health surveillance;
- Share data and knowledge across sectors at national, regional and global levels;
- Increase the capacity to respond to future cross-border threats and the surveillance and response powers of health systems.

4. Design policies based on the best available scientific evidence

Ensures that scientific evidence is used by decision makers, even when under pressure. For this, the measures are:

- Provide broad access to research data;
- Signaling confidence in new research and recognizing where it is inaccurate;
- Establish formal mechanisms for the contribution of scientists in the formulation of public policies;
- Undertake multidisciplinary work with key disciplines and specific population groups;
- Make national public health agencies central in assessing the situation and advising on strategies to be implemented;

- Strengthen the transparency, objectivity and independence of expert advice.

5. Effectively coordinate levels of government, both horizontally and vertically

Ensuring equity and policy coherence is critical. Horizontal coordination is facilitated by local emergency committees and interagency groups and tends to be easier where traditions of collaboration are well established. Vertical coordination, however, can be hindered by political competition among public administration sectors and conflicts between regional and local government agendas, necessitating formal and informal solutions to reconcile these differing perspectives. To enhance coordination efficiency, one should:

- Define roles clearly and allow them to be changed over time;
- Align the decision-making authority with the implementation responsibilities.

6. Ensure transparency, legitimacy and accountability

Given the urgency to act swiftly during emergencies while adhering to formal procedures, it is essential to promote transparency and demonstrate system reliability to safeguard against misuse. The pandemic experience suggests that:

- Flexibility of procurement procedures to allow for urgent action may weaken oversight. This risk can be minimized through public transparency mechanisms, widely disseminated;
- Where emergency legislation restricts civil liberties, external oversight becomes important, which can be carried out in a number of ways, including:

- Publish details of response measures and performance indicators;
- Support or establish parliamentary control;
- Establish specific committees or use tools to monitor responses;
- Make judicial and civil society initiatives act as scrutineers;
- Encourage transparency and protect whistleblowers.

7. Communicate clearly, coherently and transparently with the population and other stakeholders

Strengthening public health information sharing and building trust are essential. Well-presented data and participatory approaches can have significant impact. Using diverse media broadens message reach, while social networks facilitate access to harder-to-reach audiences. It is crucial that these communication channels are responsibly managed by authorities at both health system and governmental levels. A disorderly proliferation of unclear and inconsistent messages can lead to confusion. Official communication should be coordinated through a coherent strategy that actively combats disinformation, particularly on social media.

8. Engage non-governmental sectors, including health workers, civil society and communities

Experience from European Union Member States suggests that involving professional associations aids in mobilizing resources and disseminating essential information, such as scientific evidence. Engaging non-governmental actors supports policymakers in crafting appropriate responses to disruptive events impacting health systems. Sharing information with civil society builds trust, improves outreach to marginalized populations, and fosters acceptance of public health measures.

9. Coordinate the COVID-19 response across national borders

This strategy is critical to long-term success in combating a pandemic. Collaboration with other countries is valid, both in terms of preparedness and response, sharing lessons learned from previous experiences of other epidemics or outbreaks. There is scope to strengthen international preparedness against future threats, through local actions or through strengthening the role of WHO in global health governance.

10. Ensure sufficient and stable funding

The pandemic caused a major shock to health financing, necessitating the rapid reallocation of substantial resources to intensive care, new materials, and equipment, while health services faced drastic shifts in priorities. It is essential that health systems can deploy resources promptly and appropriately, ensuring equitable access to quality services for all, regardless of ability to pay. Maintaining a dedicated financial reserve for health facilitates the swift coverage of funding gaps.

11. Adapt purchasing, procurement and payment systems

Countries that responded best to the pandemic restructured their health financing mechanisms to expand services, protect key providers, and streamline hiring processes. This flexibility in reallocating resources was crucial to offset income losses for suppliers and encourage the delivery of new services in the private sector. Additionally, the introduction of new services prompted a reassessment of existing ones, leading to the discontinuation of ineffective practices.

12. Support universal health coverage and reduce barriers to access

It enhances the capacity to address new health needs arising from a crisis while maintaining essential service functions. Countries have expanded or adjusted their service portfolios to ensure independent access regardless of costs and to cover vulnerable populations. During the pandemic, reaching groups otherwise ineligible for health coverage – such as undocumented immigrants, the unemployed, and others – proved crucial due to their heightened risk of infection.

13. Ensure an adequate health workforce

All countries, despite variations in staff availability and geographic disparities, experienced increased demand and extreme pressures on health workers. Workforce shortages and uneven distribution hinder the expansion of services required during events like the COVID-19 pandemic, complicating system adaptation.

Expanding existing capacity and recruiting additional health care professionals (HCPs) requires accurate data on workforce availability and skill profiles. Similarly, adapting staff roles by reallocating tasks within teams necessitates adequate training and support. Legislation and regulations must be updated to accommodate new recruits, including provisions for insurance, pensions, and related benefits. Effective implementation demands coordination between national policies and local management responses.

14. Implement flexible and effective approaches to using the workforce

As outlined in the previous strategy, this involves altering routine team functions and reorganizing task and role allocations to meet new demands. Modifying work practices, adjusting skill mixes, and redistributing personnel to optimize staffing in hospital and outpatient settings require well-established arrangements, along with continuous monitoring and review to ensure positive outcomes for both workers and patients.

15. Ensure physical and mental health and financial support to health professionals

Given the significant impact of health crises on workers, it is essential to provide assurances that sustain commitment and reduce absenteeism, as well as physical and mental exhaustion. Supplying personal protective equipment (PPE), regular testing, and ongoing training safeguards physical health and demonstrates that workforce well-being is a priority. Offering remote counseling and other online mental health supports further aids teams working under pressure. Addressing practical needs and providing financial support to reward extra work signals recognition and commitment to healthcare professionals.

16. Implement non-pharmaceutical interventions, control or mitigate transmission

Based on measures such as social distancing, face masks, physical distancing, and vaccine passports, combined with Find, Test, Trace, Isolate, and Support (FTTIS) actions, this strategy is primarily linked to infectious disease outbreaks but also relates to essential public health functions. The presence of consistent and well-established primary health care (PHC) programs, especially those with strong community ties, was a clear advantage. Additionally, social support remains vital to the feasibility of non-pharmacological interventions.

17. Implement effective vaccination programs

This proved to be the most effective way to overcome the pandemic. In the European Union, countries had to navigate international, national, and local levels. Coordination mechanisms across countries, such as the COVAX Facility, played a vital role in facilitating vaccine access and were widely utilized during the pandemic. Multilateral efforts in public procurement and distribution provided particular advantages, especially for smaller and lower-income countries. While public investment was crucial in vaccine development, balancing performance between public and private sectors remains necessary. Careful planning and monitoring are essential for scaling vaccine distribution, and prompt legislative action is required to regulate broad vaccination programs. Communication campaigns are also critical in promoting vaccine uptake.

18. Maintain routine health services

The maintenance of regular services, including vaccination against endemic diseases, was hindered by the redirection of significant resources to combat COVID-19. Therefore, addressing the historical underfunding of public health – which the European Commission acknowledges as a continental issue – is crucial. Implementing a systemic prioritization approach for public health services can optimize institutional capacity but requires robust information systems and decision-making capabilities.

19. Expand, repurpose and deploy existing capacity to deal with sudden outbreaks

This involves ensuring capabilities are available at the right times and places. For example, countries with routinely high bed occupancy rates had limited spare capacity. To address this, additional beds were mobilized in the private sector and military facilities, and patients were transferred between hospitals, regions, and countries. Beds can only be fully operational if material capacity is maintained, which requires clear coordination and well-defined responsibility for the supply chain. Inefficiencies may occur if an excessive focus on hospital beds diverts attention from primary health care and disrupts coordination between levels of care. Infrastructure improvements must be accompanied by increases in workforce capacity and essential supplies, necessitating adequate financing and procurement systems.

20. Adapt services, make care lines more flexible and strengthen PHC

In the European experience, this strategy was vital for ensuring care for COVID-19 patients while maintaining essential services. Establishing separate care pathways for COVID and non-COVID patients helped protect both patients and healthcare workers. Having mechanisms to establish, update, and communicate guidelines to clinicians was crucial for improving case management during the pandemic. The ability to adjust and revise decisions on essential service delivery in response to the evolving epidemiological situation was also key, particularly in managing non-urgent care policies as disease severity fluctuated. Meanwhile, primary health care played a central role in managing COVID-19 outside hospitals, delivering essential care and sustaining services.

The European Commission's study offers valuable lessons on resilience from the COVID-19 experience in the region, highlighting pressures on intensive care demand and the maintenance of essential services, as well as the importance of dynamic financing, procurement, and workforce implications. Governance strategies overlap and interact; for example, tracking and translating data into policy enables authorities to better plan and guide responses, while promoting transparency and accountability through effective stakeholder communication. Communication is crucial not only for accountability but also for intergovernmental coordination and engagement with non-governmental actors.

Resilient behavior in public health should be implemented as a systematic strategy. Resilient systems must continuously integrate preventive, absorptive, adaptive, and transformative capacities, while also considering relationships with other sectors of the production system at both national and local levels – from conception through to system management. These resilient capacities underpin the various forms of system restructuring, adaptation, and service flexibility described in the strategies.

For example, education and health systems are closely linked in maintaining a properly trained workforce. Structural attributes of the system, such as workforce size and user intake capacity, are inherently interconnected and should be considered in designing health systems aimed at resilience.

The continuous development of resilience in daily services fosters transformative capacities and skills, enabling health systems to manage sudden demand surges. In already resilient services, mitigating adverse effects, adapting to the unexpected, and eventually returning to prior conditions may not require radical transformations.

The main contribution of this resilience strategy model is its association of resilient abilities – restoration, adaptation, and flexibility at various levels – with the essential functions of health systems, organized around the development cycle of an adverse event or shock. However, it overlooks the development of resilience in daily operations, which depends on the system's functional characteristics.

Summary

This chapter presents the model developed by the European Commission for building resilient strategies, centered on the functioning of essential public health functions at different stages of the shock cycle, with particular emphasis on unexpected events.

It is noteworthy that several of these strategies were systematically disregarded by senior Brazilian authorities during the pandemic, including guiding the response through effective political leadership, communicating clearly and transparently with the population and stakeholders, and designing policies based on the best available scientific evidence. Despite the efforts of local governments, scientific societies, and much of civil society, the failure to implement these strategies contributed significantly to the catastrophic impact of COVID-19 in Brazil.

Developing resilience on a daily basis – through enhancing everyday skills and emphasizing adaptation – can focus on short-term corrections without compromising essential long-term sustainable changes. We also observed that returning to pre-event conditions may be inadequate if the system had preexisting weaknesses before the crisis.

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Authors' Afterword

A paradigm is, in short, a specific vision or approach to a given problem. In The Structure of Scientific Revolutions, Thomas Kuhn explains that science periodically undergoes episodes of non-cumulative development, during which some paradigms are entirely replaced by newer ones (Kuhn, 1997). He terms "normal science" the period in which the validity of a paradigm is largely stable. If we define resilience in public health as a field – in the sense described by Pierre Bourdieu, as a structured space of positions whose properties can be analyzed independently – then resilience, although not undergoing a typical revolution, certainly cannot be regarded as normal science.

On the contrary, multiple paradigms of resilience coexist and compete, particularly within public health. For example, the paradigm of Resilience Engineering – championed by figures such as Erik Hollnagel, David Woods, Robert Wears, and, more specifically in health, Jeffrey Braithwaite – is emerging. While not yet the dominant framework for addressing health systems resilience, Resilience Engineering remains relatively unfamiliar to many public health experts, engineers, and health systems scholars.

In this book, we aim to shed light – if not fully answer – three fundamental questions about resilience in public health:

1. Is it possible to define or design a resilient health system, or at least improve its resilience? What values, objectives, functions and structures must a health system have to achieve resiliency?
2. Is it possible to determine whether a health service functions – or has the potential, skills, and conditions – to operate

resiliently and manage the variabilities of service delivery, including both routine and unexpected events?

3. How to evaluate whether a health system is potentially resilient (if it has roles, goals and objectives for this), and estimate the resilience of its services (if it has the skills to behave resiliently)?

It is important to note that research on resilience in public health reveals a consensus around adaptation to shocks or unexpected events, particularly concerning the first question above. However, there is less agreement regarding the second question, which focuses on normal functioning and the return to pre-disturbance conditions. Interestingly, a few authors emphasize the need to maintain regular services during crises. This may be an intentional strategy to use the term "resilient health system" at its broadest level, highlighting how to design a system equipped with the necessary functions and resources to handle unexpected shocks, disasters, and epidemics.

A positive aspect of this approach is the emphasis it places on attributes commonly used in the field of natural disasters – such as preparedness and robustness – as integral components of health systems. While these concepts alone do not guarantee resilient performance of services, they are crucial in designing health systems capable of adapting to extraordinary events, particularly large-scale crises like pandemics.

The widespread use of the concept of health systems resilience and its inclusion in the SDGs highlight its appeal. However, the concept is not yet sufficiently mature for straightforward operationalization. Efforts to define resilience tend to associate it primarily with sudden and severe events. Terms like "shock" and "crisis" are commonly featured in existing definitions, framing resilience as an attribute that manifests only during abrupt occurrences. Shocks are intense and sudden pressures that organizational systems face, triggered by external events. They can be immediate and short-lived, such as the floods in southern Brazil (Castro-Nunes *et al.*, 2025), or prolonged, as seen in financial crises, the COVID-19 pandemic, or the conflicts in Gaza and Ukraine.

Among notable studies applying the concept of "shock" to health systems are a Brazilian work by Bispo Júnior (2022) and a study by a British research team (Hanefeld *et al.*, 2018). These studies classify shocks into three types: acute, chronic, and political.

The first type refers to shocks that are sudden and high-impact events, such as epidemics or natural disasters. The second type encompasses the ongoing, daily challenges faced by health systems, including structural difficulties, chronic underfunding, fragile technical capacity, and workforce shortages. The third type involves tensions arising from the implementation of new policies or reforms that have significant potential to cause instability, such as changes in governance, financing mechanisms, or service delivery models.

This classification shows that the concept of health systems resilience is evolving from focusing mainly on the first type (acute shocks impacting system functions and structures) to encompassing the second type (chronic or political shocks that affect service performance). This shift implies that for a health system to be considered resilient, both its design and operation must be grounded in the core principles of resilience (Jatobá & Carvalho, 2024).

Broader approaches use terminology that links resilience not only to sudden, high-intensity events but also to everyday functioning, highlighting that resilience manifests both during acute shocks and in routine, often less visible, situations.

This delimitation is an important step toward situating resilience within a tangible framework, recognizing that the boundaries of its definitions may vary. Most importantly, it guides the use of distinct assessment methods and indicators for two key questions: (1) incorporating resilience objectives, and (2) operating resiliently.

A more comprehensive approach broadens the relevance of resilience beyond sudden crisis response, facilitating consideration of various contextual factors – such as environmental, demographic, or political issues – that can lead to profound and lasting changes in health system functioning.

The clear distinction between sudden shocks, slower impacts, less intense events, and chronic stressors helps establish that health systems must maintain continuous resilience. This capacity to adapt to ever-changing conditions and unexpected developments presents new challenges – or opportunities – to deliver quality services amid ongoing variability, including organizational and political instability, workforce turnover, and shifting user expectations.

Strengthening the notion of everyday resilience also helps differentiate the development of resilient behavior from mere crisis management – a concept often linked to health system resilience, grounded in specific theoretical-methodological frameworks and supported by a broad set of context-dependent guidelines and strategic recommendations, varying by crisis type, geographic area, intensity, and scope.

A resilient health system must, of course, be able to manage crises. After all, promoting resilient behavior requires mobilizing crisis management tools. However, health system resilience – as a systemic attribute – entails a broader construction, where crisis management is only one of many instruments. Confusion often arises when resilience is viewed as a program to implement or a result to achieve, as noted in the preamble to Part I. Ultimately, crisis management is one necessary element for a health system to develop its full potential for resilient performance.

A continuing challenge is the development and application of theoretical and methodological frameworks suited to promoting more resilient health systems. It is necessary to conceive functions based on the daily enactment of resilient operation, so that resilience is characterized not only as a system outcome but also as the specific ability (or set of skills) to manage available resources, alongside the capacity to maintain regular services during periods of stress. Regardless of whether qualitative or quantitative approaches are used, assessments must be able to capture the potential of health systems to perform their functions resiliently, in line with these fundamental properties.

The effort described in Chapter 14 to assess the resilient potential of traditional health system functions, based on PAHO's conceptual framework, highlighted the challenges of using very general frameworks to promote systems' capacities for adaptation, preparedness, and robustness. Although the essential functions of health systems provide a common frame of reference and a familiar way to study their operation, it is important to recall that PAHO's framework is itself based on the WHO's building blocks framework, which was originally designed for a specific type of disruption – climate change. Moreover, the essential functions listed by PAHO primarily focus on routine health service delivery and management, without clearly incorporating components or attributes explicitly aimed at responding to unexpected situations. This supports our argument (and that of other authors) that resilience develops daily but becomes most visible during crises. Therefore, measuring the potential of health systems for resilient behavior will never be straightforward.

Beyond the WHO framework and the essential functions proposed by PAHO for the Americas, the ability to anticipate and manage uncertainties depends on access to flexible and adaptable resources. However, perceptions of problems and their long-term impacts on health system functioning often vary significantly depending on local realities. Factors such as poverty, precarious housing, irregular access to clean water, education, and social protection are key determinants of a community's capacity to mitigate disaster risks and impacts. These, along with other interconnected dimensions, are not always fully understood or accessible to frontline workers.

The WHO Building Blocks framework was developed as a tool to guide government investments in strengthening health systems, rather than as an analytical or explanatory model. Its indiscriminate use in analyzing the potential for resilience in public health tends to overlook the role of people – both workers and patients – in system behavior, while also failing to fully capture structural weaknesses in specific contexts.

Likewise, the scope of health systems resilience varies not only between countries but also within them, influenced by differing levels of grievances, local governance arrangements, federative pacts, and more. It is therefore unsurprising that situated or local definitions of resilience scope are developed, as the WHO suggests. The capacity for adaptation and recovery, as well as the ability to sustain essential functions during crises, depends on a complex mix of political, socioeconomic, and cultural factors. The COVID-19 pandemic demonstrated that even health systems in wealthy countries can exhibit low resilience capacity.

The field of public health is undeniably complex. A health system's resilience depends not on success in just one or a few skills, but on maintaining awareness across a broad range of competencies. Crisis situations often exacerbate inequalities, particularly where local capacities are limited or among vulnerable communities that tend to be disproportionately affected.

Much of the research reviewed in this book recognizes that a health system's resilience potential is strengthened only through extensive understanding of its contexts and populations. Health systems comprise numerous components that interact with each other, making them inherently difficult to model due to the dependencies and relationships among their parts, their environments, or with other systems. Consequently, there are many ways to study resilience. Many authors, therefore, link the term resilience with other concepts, especially when addressing health system resilience in programs and policies.

Every organization is continually subject to change and its effects. This is especially positive in complex systems like public health, where change – or more precisely, the ability to anticipate and respond to it – drives evolution. The better an organization adapts to new situations, the greater its potential for everyday resilience. Managing change – whether triggered by sudden disruptions or driven by institutional or political commitments – places resilience at the core of management models in a context where new disruptive events are always possible.

In the exact sciences, such as physics and engineering, resilience is a property of materials that can be measured objectively. In contrast, as an attribute of health systems, measuring resilience objectively becomes challenging due to the concept's inherent complexity. Among efforts to quantify system resilience, the public health community primarily relies on quantitative methods, especially epidemiology (see Chapter 8). This reliance may raise questions about the credibility of more subjective assessments of system behavior, particularly regarding its potential for resilient performance.

There is also a need to respond to the calls from international agencies on resilience, particularly for countries that are signatories to the WHO or the 2030 Agenda. Assessing the dimensions of resilience involves taking into account the complexities inherent to it, which are explored through a myriad of theories (see Chapter 10).

The notion of health systems resilience remains diffuse – not because it is poorly developed, but because there are several different conceptions that, while sharing some common aspects, vary significantly. This plurality of meanings depends on how a health system is perceived and what it aims to achieve through resilient performance. It is a field still in active exploration, where existing conceptual frameworks are nascent, have been little tested, and are therefore not yet fully consolidated.

Acronyms

CDC – Center for Disease Control and Prevention;

CENDES – Venezuela Development Center;

CHW – Community Health Worker;

CIEVS – Strategic Information Center for Health Surveillance;

CIINFO – Health Information and Informatics Committee;

COAP – Organizational Council for Public Health Action;

CPPS – Pan American Center for Health Planning;

CTA – Cognitive Task Analysis;

CWA – Cognitive Work Analysis;

DATASUS – Information Technology Department of the Unified Health System;

E-Digital – Brazilian Strategy for Digital Transformation;

ECLAC – Economic Commission for Latin America and the Caribbean;

ENSP – Sergio Arouca National School of Public Health;

EPSJV – Joaquim Venâncio Polytechnic School of Health;

ESF – Family Health Strategy;

EWA – Ergonomic Workplace Analysis;

FGV – Getúlio Vargas Foundation;

FIOCRUZ – Oswaldo Cruz Foundation;

FNS – National Health Fund;

FRAM – Functional Resonance Analysis Method;

FTTIS – Find, Test, Trace, Isolate and Support;

GHSI – Global Health Security Index;

HCI – Human-Computer Interaction;

HCN – Health Care Network;

HEIC - Health Economic-Industrial Complex;

HERA – Health Emergency Preparedness and Response Authority;

HSA - Health Situation Analyses;

ICT – Information and Communication Technology;

ICU – Intensive Care Unit;

IEA – International Ergonomics Association;

IHR – International Health Regulations;

IPE – Individual Protective Equipment;

ISC – Institute of Collective Health of the Federal Fluminense University;

NHS – National Health Service;

OECD – Organization for Economic Co-operation and Development;

PACS – Community Health Workers Program;

PAHO – Pan American Health Organization;

PHC - Primary Health Care;

PHEIC – Public Health Emergency of International Concern;

PNAB – National Primary Care Policy;

PNIIS – National Health Information and Informatics Policy;

PPGI – Graduate Program in Informatics at the Federal University of Rio de Janeiro;

RAG – Resilience Analysis Grid;

RNDS – National Health Data Network;

SAMU – Mobile Emergency Care Service;

SDG – Sustainable Development Goals;

SES – State Health Department;

SI-PNI – National Immunization Program Information System;

SIA – Ambulatory Information System;

SIAB – Primary Care Information System;

SIH – Hospital Information System;

SINAN – Information system for Notifiable Diseases;

SINASC – Live Birth Information System;

SINPDEC – National Civil Defense and Protection System;

SISAB – Health Information System for Primary Care;

SISREG – Access Prioritization System;

SMS – Municipal Health Department;

SoHEU – European Commission's State of Health in the EU;

SoS – System-of-Systems;

SUS – Unified Health System;

SVS – Health Surveillance Department;

UFBA – Federal University of Bahia;

UFF – Fluminense Federal University;

UFRJ – Federal University of Rio de Janeiro;

UFSCAR – Federal University of São Carlos;

UHC – Universal Health Coverage;

UN – United Nations Organization;

UNDRR – United Nations Office for Disaster Risk Reduction;

USAID – United States Agency for International Development;

USP – University of São Paulo;

WAD – Work-as-Done;

WAI – Work-as-Imagined;

WHO – World Health Organization.

Figure and Table Index

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Subject Index

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Health Systems Resilience:

Refers to the adaptive capacity that health systems must develop and sustain in order to respond effectively to sudden increases in demand resulting from extraordinary events that directly or indirectly affect population health.

At the same time, it requires ensuring the continuity of system functioning, as well as the safety, quality, and availability of services.

Health systems resilience reflects the extent to which a system is able to continuously prevent, detect, and mitigate harm, or reduce the likelihood of adverse incidents.

Definition adapted from the Health Sciences Descriptors (DeCS/MeSH)/PAHO

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