Public Health Architecture

Eight Guiding Principles for the Digital Transformation of the Health Sector

Digital transformation toolbox
ORGANIZATION, COORDINATION, AND DEVELOPMENT

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Abstract

**Public health architecture** is one of the eight guiding principles for the digital transformation of the health sector promoted by the Pan American Health Organization (PAHO). This policy brief presents key concepts, recommended lines of action, and monitoring indicators, with the objective of advancing the architecture of public health.

According to the PAHO definition, this guiding principle aims to **design public health care architecture in the era of digital interdependence**:

Public health architecture in the era of digital interdependence must be framed within each government’s digital agenda. It must be transversal in order to include the different aspects of governance and optimize strategic planning and resource management. It should be based on the use of standards and procedures that favor multiple areas, not only the health field. This is the case of connectivity and bandwidth, which have an impact on health, education, and all other sectors (1).

Most advances in digital health occur as individual applications and information systems that work independently. This generates islands of information, posing major challenges to achieving efficiency and improving health outcomes. The PAHO proposal is intended to create an architecture for health that serves as a platform for different information systems to interoperate, working together in an integrated manner. There are different ways to achieve this data exchange, and all of them involve establishing governance, a framework of trust (generated through regulations and compliance), and an architecture for technological interoperability.

From a technical standpoint, the existence of multiple systems with a high degree of fragmentation means that such a strategy should be oriented towards maintaining the core functionality of legacy systems while investing in an adaptable infrastructure, with an open architecture and solutions based on web services or application programming interfaces to support a new connected ecosystem.

This policy brief is intended for decision makers and planners in the health sector, as well as organizational and business architects who are responsible for the design of national digital health systems, regardless of the level of digital development in each country. The brief begins by conceptually addressing the principle of information architecture in public health, and then describes its current state of implementation in the Region of the Americas and identifies the main challenges. This is followed by a presentation of lines of action and specific recommendations for their implementation, and finally, of the monitoring indicators suggested for their evaluation.

**Keywords**: health information systems, interoperability, health data exchange, digital health, standards, data governance, information systems security.
Introduction

Public health faces significant challenges in the Region of the Americas. To address them, it is essential to strengthen essential public health functions in each country to advance towards universal access to health care and coverage, while also expanding this concept to encompass food security, control of zoonoses, resistance to antibiotics, care for biodiversity, and protection of the environment under the umbrella of “One Health”. Public health information systems play a central role in supporting all these activities.

The Pan American Health Organization (PAHO), supported by its Member States, launched the “Eight Guiding Principles for the Digital Transformation of the Health Sector” initiative as part of its Strategy and Plan of Action on Information Systems for Health. The eighth principle involves designing public health architecture in the age of digital interdependence. The term health information architecture refers to a detailed plan for how information is stored, organized, and used in health organizations by their systems and users.

Given the fragmented health systems that exist in each country of the Region, a pragmatic approach should be based on achieving adequate communication between them, rather than trying to replace them with a potential single solution. Moreover, it is necessary to think about communication with other external systems whose information is relevant to health. Therefore, interoperability becomes another fundamental principle linked to public health architecture.

There are different ways to achieve this data exchange and all of them involve establishing governance, a framework of trust (generated through regulations and compliance), and an architecture for technological interoperability.

An effective information architecture must address the issue of interoperability across data silos and serve as a guide for the transition to shared data and streamlined workflows. Work processes and system interfaces need to be made more flexible to adapt to inevitable changes. This ecosystem of applications must maintain the independence of each agency in the management of health data, but also enable the exchange of information when necessary and permitted.

The proposal for a digital health platform is based on the concept of a service-oriented architecture, where discrete and interoperable services solve information needs from public and non-public health perspectives. This approach provides access to reusable resources that are taken as a primary source, including reference records, identity authentication, or data repositories, which can be managed by different stakeholders. By focusing efforts on creating added value on a common basis, this approach avoids reinventing the wheel.

Different solutions to connect different systems using interoperability standards include the following: centralized, such as an interoperability bus; distributed, through such data exchange solutions as X-Road® or National Health Stack; or hybrid. Identifying the best option for each country depends on multiple factors that must be analyzed to make an informed decision.
To design an adequate public health architecture, it is essential to identify the state of the situation and the gaps and opportunities existing in the Region.

The response to the coronavirus disease (COVID-19) pandemic has highlighted the need for systemic changes to achieve effective digital solutions. Policies, laws, and guidelines should be reviewed and updated to ensure the ethical use of data, interoperability, and cybersecurity. It is essential to support digital literacy and access for all, with special attention to those groups in situations of greatest vulnerability.

Regarding perceived barriers, the experts consulted highlighted the lack of priorities and of continuity in policies to promote digital transformation in health. Furthermore, connectivity and the level of implementation of electronic tools in health institutions is still low, far surpassed by the use of paper. Even in more digitalized environments, the absence of incentives for institutions (and other stakeholders) to join a public health architecture limits data sharing. The experts also mentioned the high degree of fragmentation of information systems, lack of standardization of processes, and deficits in infrastructure and trained human resources.

As stated in the technical recommendations for the Digital Health Cooperation Network of the Americas (known by its Spanish acronym, RACSEL), Regional Challenges for Electronic Health Implementation (8), the socioeconomic reality of many of the countries of the Region cannot be ignored when addressing a digital transformation project in the health sector. The scarcity of both economic and human resources can be a major obstacle, which should not be underestimated. Vision and leadership skills must be accompanied by strong managerial skills, pragmatism, perseverance, and political savvy. According to an analysis by the Inter-American Development Bank (IDB), only 14 countries in the Region have formalized their digital health agendas (8).

In some countries, federalism can be a challenge when developing such agendas, because coordination of central and local governments is required to harmonize policies and strategies. Different studies on the regulatory frameworks of countries in the Region have found that there is usually some kind of regulation regarding electronic medical records (9). However, only 38% of countries cover the key dimensions, and in general, they are deficient in terms of interoperability and use of standards (10). These findings give an idea of the progress made, and pending efforts, in the regulatory field.

Digital health strategies that have continuity, despite changes in government management, are those that feature medium- and long-term planning, with governance mechanisms and economic sustainability. Uruguay provides a striking example: the Salud.uy project is part of a broader e-government program led by a specific agency, with independence and dedicated funding that includes international funds, and which has made sustained progress for more than 15 years.

Different organizations and consortia are promoting the identification and dissemination of good practices, including the World Health Organization (WHO), with its Global Strategy on Digital Health 2020–2025 (11), Digital Implementation Investment Guide (12) and...
Digital Health Platform Handbook (13); PAHO, with the Eight Principles for the Digital Transformation of the Health Sector (1); the Principles for Digital Development (14); the Global Digital Health Partnership (GDHP) (15); RACSEL (16); communities of practice, such as OpenHIE (17); and IDB (9) and the World Bank (18).

The PAHO approach to providing technical assistance on digital health seeks to strengthen the leadership capacity of the ministries of health in each Member State, which is why it has created the Information Systems for Health (IS4H) toolkit (19). Several Latin American countries are already working on their own digital health strategies based on IS4H recommendations, including maturity assessment with the ISH4 Maturity Model tool (20).

Countries such as Argentina, Brazil, and Uruguay have rolled out data exchange platforms at the national level, including the creation of an interoperability bus, to interconnect their different existing systems. The interoperability bus provides the backbone of service-oriented architecture. An analysis of gaps that need to be addressed to achieve a regional health architecture for the five RACSEL member countries (21) concluded that two of these countries are in optimal conditions to advance in cross-border integration: Costa Rica and Uruguay. The remaining countries (Chile, Colombia, and Peru) must first solve issues in their own national networks, with different challenges in the domains of infrastructure and communications, standards, security and auditing, and systems governance.

There are initiatives in the Region to evaluate emerging technologies with a view to defining these cases and how they could be used for the benefit of society.

The Network of e-Government Authorities of Latin America and the Caribbean (GEALC) published a general guide for the adoption of large information assets (big data), artificial intelligence, and blockchains and distributed ledger technologies. Reference frameworks are also emerging in the health field, such as the WHO guidelines for assessing digital health implementation, and its guidance on the ethical use of artificial intelligence in health.

There are examples of information systems projects in the Region and around the world that have not been as successful as expected, sometimes due to poor approaches to addressing resistance to change. The introduction of a new health information system requires a serious effort to manage such change, involving simultaneous organizational, human, and technological interventions.

There is a significant shortage of professionals who are both knowledgeable about technologies and information systems and have a deep understanding of the public sector and civil society context where the change will be implemented (22). Moreover, strategies, methods, and tools are needed that are integrated into all phases of the design and implementation process (23). As part of change management, predictive analyses of technology acceptance can be carried out; for example, to assess perceptions of usefulness and user-friendliness, which are of great cultural importance. Although there are experiences of this type in the Region, they are usually isolated or research cases, rather than ones using a systematic approach to this type of project at the national level.
Lines of action

In the era of digital interdependence, public health architecture must be framed within each government’s digital agenda, and be cross-cutting to coordinate the different aspects of governance and optimize strategic planning and resource management. Moreover, this architecture should be based on the use of rules and procedures furthering multiple areas, not only health.

PAHO proposes information security as one of the eight guiding principles for the digital transformation of the health sector (1, 24, 25), with the following lines of action:

1. Update digital agendas as a public policy that contains the necessary regulatory framework for digital applications in health.
2. Leverage international efforts to develop projects for the implementation of health information technologies.
3. Consider deploying the necessary technologies to enable data exchange (for example, an interoperability bus) with services consulting standardized databases for national benefit and use.
4. Define processes to evaluate emerging technologies linked to big data, machine learning, artificial intelligence, blockchains, and omics sciences, among others.
5. Create change management teams to facilitate digital transformation, specifically in the health setting, and consider the particular needs of the different stakeholders in the health system (such as patients, health professionals, administrative personnel, leaders, and coordinators).
6. Introduce new underlying frameworks for predicting the adoption and use of technology in the health sector, from the perspective of providers and of users.
7. Formulate mechanisms to seek, promote, and exchange information on good practices. Likewise, create effective mechanisms for the exchange of knowledge to avoid reinventing the wheel in different sectors and locations.

All the experts consulted agreed that, to develop a public health architecture, the focus must be on strategic planning, training specialized human resources, continuity in government policies (digital agendas applied to health and the environment), and investment in technological infrastructure. They also highlighted the importance of building consensus for data standardization and governance, as well as working on the constant improvement of data quality and the evaluation of long-term results. From a technical standpoint, the existence of multiple highly fragmented systems means that the strategy should aim to maintain the core functionality of legacy systems while investing in an adaptable, open-architecture infrastructure, and solutions based on web services or application programming interfaces to support a new connected ecosystem.

Specifically, the proposed lines of action to advance the definition of a public health architecture are those set out below.

1. INCORPORATE THE VISION OF HEALTH INTO NATIONAL E-GOVERNMENT AGENDAS, AS PUBLIC POLICY

- Align the digital health strategy with the country’s health priorities
- Ensure governance by involving key stakeholders in the development, validation, and implementation of the strategy
- Adapt the regulatory framework to achieve the digital transformation of the health sector
- Prioritize the different areas of systems so that they report directly to the highest level of strategic decision of the Americas. The experts identified points of reference for the topics addressed by the guiding principles.

2 On 23 November 2021, an asynchronous policy dialogue was convened, together with PAHO, to advance in implementing a road map for the digital transformation of the health sector in the Region
making; and as service providers, they should be cross-cutting to all areas

- Map out medium- and long-term projects (3-year, 6-year, and 10-year projects), seeking to provide sustainability, predictability, and legal security

- Establish achievable milestones in the short and medium term (quick wins), understanding the need to obtain visible results to achieve political and popular support for this type of initiative, without losing sight of long-term goals

- Seek multi-year funding to give sustainability to the strategy, even with changes in government management

2. LEVERAGE INTERNATIONAL EFFORTS TO DEVELOP PROJECTS FOR THE DEPLOYMENT OF INFORMATION TECHNOLOGIES IN HEALTH

- Convene national and international experts with experience in the area

- Conduct surveys on the state of the art, including experiences from other countries

- Evaluate the use of regional or global public goods supported by an active community, or solid, sustainable business solutions, respecting technological neutrality, before deciding to start developments from scratch

3. CONSIDER DEPLOYING THE NECESSARY TECHNOLOGIES TO ENABLE DATA EXCHANGE

- Adopt platform-based technological solutions that enable a service-oriented architecture (such as an interoperability bus or decentralized systems), prioritizing data security

- Identify and make available consultation services to standardized databases of national benefit and use (including registries of patients, professionals, and institutions; guides to prescription drugs; lists of diagnoses; and clinical entities)

- Evaluate the incorporation of international standards for disease classification and diagnoses, as well as terminological services for complex health concepts (background, diagnoses, medications, laboratory tests, practices, and procedures)

- Identify the existing information systems in a national catalog, promoting their adaptation to interoperability standards and steadily incorporating certification processes

4. DEFINE PROCESSES TO EVALUATE EMERGING TECHNOLOGIES LINKED TO BIG DATA, MACHINE LEARNING, ARTIFICIAL INTELLIGENCE, BLOCKCHAIN, AND OMICS SCIENCES, AMONG OTHERS

- Involve regulatory or health technology assessment agencies, adding the experience of relevant digital health stakeholders (including universities, scientific societies, non-governmental organizations, and patient representatives)

- Adopt systematic mechanisms for evaluating and validating technologies

- Encourage locally generated research studies and publication of works on digital health, and their distribution

- Promote debates on ethical and legal aspects of new technologies, prioritizing human rights protection

5. TRAIN SPECIALIZED HUMAN RESOURCES WHO CAN FORM INTERDISCIPLINARY TEAMS FOR DIGITAL TRANSFORMATION

- Promote the incorporation of digital health issues into undergraduate studies in the health sciences, public administration and management, and computer science

- Forge partnerships with training institutions (such as universities, hospitals, and institutes) that offer postgraduate programs in digital health or computer science applied to health, or that can create them

- Incorporate digital health into ongoing training for health personnel

6. INTRODUCE NEW UNDERLYING FRAMEWORKS FOR PREDICTING THE ADOPTION AND USE OF TECHNOLOGY IN THE HEALTH SECTOR, BOTH FROM THE
PERIODIC PERSPECTIVE OF PROVIDERS AND OF USERS

- Consider the digital divide, the situation of minorities, and the lack of health literacy when planning implementations, to leave no one behind

- Promote user-centered design, a positive user experience, and other techniques that seek to optimize the usability of health information systems

- Prioritize education in aspects of change management in health settings, addressing the needs of the different stakeholders (including patients, health professionals, administrative staff, leaders, and coordinators)

7. FORMULATE MECHANISMS TO SEEK, PROMOTE, AND EXCHANGE

INFORMATION ON GOOD PRACTICES AND KNOWLEDGE TO DRAW ON EXPERIENCES FROM DIFFERENT PLACES AND SECTORS

- Create alliances with national and international organizations that work on digital health projects, such as universities, standards organizations, cooperation networks, non-governmental organizations, and multilateral credit institutions

- Participate in spaces for the exchange of experiences in digital health with countries across the Region and the world
Monitoring indicators

To advance the development and implementation of the public health architecture, the following indicators are proposed. It is important to clarify that they are general. This is not an exhaustive list; each country or region can incorporate others, defining the level of disaggregation necessary and frequency of measurement.

CROSS-CUTTING INDICATORS TO ALL EIGHT GUIDING PRINCIPLES FOR DIGITAL TRANSFORMATION IN HEALTH

• A national digital health strategy established through a regulatory framework
• A governmental organization structure for leading the digital transformation strategy in health
• A budget for a digital agenda that includes human resources and the necessary technology

SPECIFIC PUBLIC HEALTH ARCHITECTURE INDICATORs FOR EACH LINE OF ACTION

1. Incorporate the vision of health into national e-government agendas, as public policy
   • Digital health strategy
   • Data governance agreements in the health area
   • Enabling regulatory framework for the electronic exchange of health data

2. Leverage international efforts to develop projects for the implementation of health information technologies
   • Government involvement in international digital health initiatives
   • Bureau or committee of experts to advise the government on digital health

3. Consider deploying the necessary technologies to enable data exchange
   • Information architecture proposal (interoperability)
   • Data interoperability infrastructure (centralized or distributed platform)
   • Defined interoperability standards
   • Identification of reference records (persons, professionals, institutions)
   • Recommendations or systems for the unique identification of people or patients
   • Number of existing health information systems
   • Number of health processes mapped
   • Proportion of identified systems adopting defined standards
   • Proportion of identified systems joining the interoperability platform
4. Define processes to evaluate emerging technologies linked to big data, machine learning, artificial intelligence, blockchains, and omics sciences, among others

- Number of interoperating systems versus total systems
- Number of people or patients identified on the platform
- Number of transactions per day through the platform

5. Train specialized human resources who can form interdisciplinary teams for digital transformation

- Health technology assessment body for information and communications technologies (ICTs)
- Annual number of reports on health technology assessment for ICTs
- Number of publications by national authors on digital health in indexed journals

6. Introduce new underlying frameworks for predicting the adoption and use of technology in the health sector, from the perspective of providers and of users

- Population representativeness in digital health in government (female quotas, ethnic minorities, gender diversity)
- Default accessibility policies in systems creation, specifically in health
- Inclusion of usability as an evaluation metric for health applications

7. Formulate mechanisms to seek, promote, and exchange information on good practices and knowledge to draw on experiences from different places and sectors

- Participation of local referents in international health events and congresses
- Local affiliates of health standards organizations, such as Health Level Seven International (HL7)
- Creation of maturity models to be promoted as a form of diagnosis, evaluation, and monitoring

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A maturity model is a set of structured levels that represent the organizational behaviors, practices, and processes that reliably and sustainably produce the required results. There are several initiatives to measure the level of digitalization of health systems; specifically, their architecture, integration, and interoperability aspects. The IS4H Maturity Model (MM-IS4H) assessment tool is a PAHO initiative to support the countries of the Region in their initial evaluation and monitoring. It has five possible levels, enabling a diagnosis of the situation, the assignment of priorities, and periodic measurement to observe progress and challenges.
General recommendations

The advancement of public health architecture is not limited to technological development. In addition to the technical capabilities needed to create it, key enablers such as governance, financing, the regulatory framework, and human resources are required to develop or use digital health tools. Countries must steadily evolve these enablers to reap the full benefits of technology.

A comprehensive explanation of the steps to adopt an interoperability platform can be found in the WHO Digital Health Platform Handbook (13), published in 2020. When planning public health architecture, it is crucial to take a holistic view. One reason to consider the overall context of the health system is to ensure that the platform and its external applications and systems are aligned with the country’s health goals. The digital health strategy defines the changes expected to strengthen the health system and to improve certain health outcomes and indicators. This defines which digital interventions are necessary, and if any process needs to be redesigned. The design of the interoperability platform involves defining the need to modify existing systems or create new ones, including reusable components, such as reference records. Finally, how to implement, sustain, and scale the interoperability platform must be defined from a technical point of view (see figure).

There are different reference architectures for designing a platform. The architecture proposed by the OpenHIE community of practice (17) comprises patterns to ensure that health information from different external systems can be brought together in a unified system and can be recreated using different software and standards. Its technical components enable healthcare organizations to capture, store, manage, and share information across key dimensions. While each component plays a critical role, the sum of the system is greater than its individual parts. Another widely used reference model is the TOGAF® Standard (27), which contains a step-by-step method for designing an enterprise architecture.

To measure the level of progress of the strategy with respect to the architecture, one or more maturity models appropriate to the context can be selected, choosing all the relevant or necessary indicators. Using the model as a roadmap can help mark milestones and explain to stakeholders how to move forward at each stage.

Phases of designing an interoperability platform

Digital health strategy
Identification of needs and areas for improvement
Design of the digital platform
Deployment, support, and scaling
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