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20 YEARS ICT SURVEYS

ICT in Health

SURVEY ON THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN BRAZILIAN HEALTHCARE FACILITIES

2024

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Brazilian Network Information Center

ICT in Health

SURVEY ON THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN BRAZILIAN HEALTHCARE FACILITIES

2024

Brazilian Internet Steering Committee
www.cgi.br

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2025

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Contents

List of charts

List of tables

List of figures

Foreword

A successor to Arpanet, the Internet was maintained in its first decades by research funds, such as the National Science Foundation (NSF) in the United States, and by the institutions connected to it. Throughout this period—which lasted until the mid-1990s—the Internet was used mainly for the communication of supercomputing centers and universities, without aiming for self-sustainability. With its widespread dissemination more than three decades later, we can say that the Internet has become mature, and is made up of a very complex ecosystem structured on layers of physical infrastructure, connection protocols, and a wide range of applications.

This maturation process, in addition to the search for Internet sustainability, has involved technical challenges of scalability and security, in addition to interaction with political and regulatory bodies. It has gone through many stages and an extensive multisectoral and international effort to define Internet governance arrangements that are capable of balancing diverse interests and guaranteeing stability, interoperability, and expansion. In the Brazilian case, the establishment of multisectoral, democratic, and collaborative governance was solidified with the creation of the Brazilian Internet Steering Committee (CGI.br) and the institutionalization of the Brazilian Network Information Center (NIC.br), which includes Registro.br, responsible since 1989 for registering domain names with the "last name" .br. In this way, it was possible to guarantee not only the Internet governance framework, already defined by Standard 4 of 1995, but also self-sufficiency in the technical management of names and numbers, making it possible to reinvest in the expansion and improvement of the Internet infrastructure in Brazil.

In addition to managing the registration and publication of .br domain names, and allocating autonomous system numbers (ASN) and Internet protocol (IP) addresses in versions 4 and 6, it carries out a number of other actions, all linked to the promotion of fundamental values for the Internet, such as integrity, interoperability, and accessibility.[1] These actions include supporting research centers with funds from Registro.br, holding national and international events, and promoting actions aimed at expanding the infrastructure and protecting users on the Internet, always with the goal of making the Internet increasingly accessible and safe. Another fundamental aspect is CGI.br's role in fostering constant and careful dialogue about the use of the Internet by individuals, enterprises, and the government.

[1] More information at https://principios.cgi.br/sobre

While technological advances bring countless possibilities, it is also true that new challenges need to be faced collectively if the Internet's guiding principles are to be preserved. In recent years, for example, the growing adoption of mobile devices and Artificial Intelligence (AI) technologies by individuals and organizations has brought to the fore issues such as privacy and data protection, the proliferation of false or misleading content, and the potentially harmful excessive use of digital devices by children. Several events promoted by NIC.br in 2024 addressed these issues, enabling multisectoral reflections anchored in data. Some examples are the 15th edition of the Seminar on Privacy and Personal Data Protection,[2] the 9th Symposium on Children and Adolescents on the Internet,[3] and the seminar launching the Brazilian Artificial Intelligence Observatory (OBIA),[4] which operates under NIC.br.[5]

It is also worth highlighting the participation of CGI.br and the collaboration of NIC.br in various G20 initiatives during Brazil's presidency in 2024. To contribute to the debate on the digital economy, the Regional Center for Studies on the Development of the Information Society (Cetic.br)—a department of NIC.br dedicated to the production of indicators and analyses—has been active in the production of three reports on topics considered to be priorities by the G20 that are fundamental to the dialogue on technology and society. These publications had important international organizations as partners: the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Telecommunication Union (ITU), and the Ministries of Science, Technology and Innovation (MCTI) and Communication (MCom). The first summarizes indicators on the state of AI development in the G20 countries,[6] while the second focuses on the adoption of AI in public services.[7] The third proposes a framework for the international measurement of meaningful connectivity.[8]

Cetic.br|NIC.br is also responsible for a series of other publications that provide a detailed overview of the use of information and communication technologies (ICT) by individuals and organizations in Brazil. In addition to publishing research on ICT adoption in different segments, such as households, enterprises, governments, education, and health, the Center conducts sectoral and cross-cutting studies with a national scope on topics such as meaningful connectivity, AI in health, privacy and data protection, and electronic waste.

In 2025, Cetic.br|NIC.br celebrates two decades of work dedicated to producing reliable indicators and analysis on the use of ICT in Brazil. Over these 20 years, it has established itself as a national and international benchmark in the generation of comparable data, which provides important input for policymaking, the development of academic research,

[2] More information at https://seminarioprivacidade.cgi.br/

[3] More information at https://criancaseadolescentesnainternet.nic.br/

[4] More information at https://seminarioobia.nic.br/

[5] More information at https://obia.nic.br/

[6] More information at https://cetic.br/pt/publicacao/toolkit-for-artificial-intelligence-readiness-and-capacity-assessment/

[7] More information at https://cetic.br/pt/publicacao/mapping-the-development-deployment-and-adoption-of-ai-for-enhanced-public-services-in-the-g20-members/

[8] More information at https://cetic.br/pt/publicacao/universal-and-meaningful-connectivity-a-framework-for-indicators-and-metrics/

and strengthening the multisector debate on digital transformation. Its commitment to methodological rigor and excellence in the production of knowledge has strengthened its position with international organizations, governments, and civil society, making it an important pillar in building a more inclusive and sustainable digital environment.

The publication you have before you is part of this trajectory and reflects the conceptual and methodological knowledge of Cetic.br|NIC.br. In it, you will find essential data and evidence to understand how Brazilian society has been appropriating these technologies over the last two decades, a period marked by significant advances and complex challenges emerging from the digital age. This celebration is not only an institutional milestone, but also an invitation to reflect together on the future of ICT research and the role of data in building policies and strategies for a connected and informed society.

Enjoy your reading!

Demi Getschko
Brazilian Network Information Center - NIC.br

Presentation

Throughout 2024, the Brazilian Internet Steering Committee (CGI.br), in conjunction with the Brazilian Network Information Center (NIC.br), actively participated in national and international debates on the challenges for the governance of the digital environment, reaffirming its commitment to an inclusive and sustainable future for Brazil and the world. In particular, it is worth highlighting the NetMundial+10 Conference,[1] held in April 2024 by CGI.br. The Conference has established itself as a multisectoral platform for dialog on the challenges of Internet governance in a scenario in which digital technologies profoundly transform social, economic, cultural, informational, and political relations. The meeting culminated in the document *NetMundial+10 Multistakeholder Statement: Strengthening Internet governance and digital policy processes*,[2] which has become a reference on global agendas.

Also in 2024, during its presidency of the G20, Brazil took on a leading role in promoting sustainable development, social inclusion, and the reform of global governance. With a focus on reducing inequalities and fighting hunger and poverty, the country promoted debates on the energy transition, climate change, and key issues related to the digital economy. Brazil's chosen priorities in the G20 Digital Economy Working Group (DEWG) also reflect its commitment to a more inclusive and sustainable digital economy, including topics such as meaningful universal connectivity, advancing digital government and digital public infrastructures, promoting information integrity and a more secure digital environment, and Artificial Intelligence (AI) for sustainable development and reducing inequalities.

With the prominent and collaborative work of the Ministries of Science, Technology and Innovation (MCTI), Communications (MCom), Management and Innovation in Public Services (MGI), and the Secretariat for Social Communication (Secom), these priorities were considered strategically, in line with the challenges of the digital economy. NIC.br and CGI.br played an important role in several of these activities, contributing their technical expertise and commitment to multisectoral Internet governance, such as the leadership of the Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of NIC.br, in three publications related to the priority themes.[3]

[1] More information at https://netmundial.br/

[2] The Statement can be accessed at https://netmundial.br/pdf/NETmundial10-MultistakeholderStatement-2024.pdf

[3] Toolkit for Artificial Intelligence Readiness and Capacity Assessment; AI for enhanced public services in the G20 members: Artificial Intelligence for inclusive sustainable development and inequalities reduction; and Universal and meaningful connectivity: A framework for indicators and metrics.

At the same time as the international meetings, the 5th National Conference on Science, Technology and Innovation (CNCTI) was held in Brasilia. The meeting, which was open and participatory, was attended by more than 2,500 representatives from civil society, academia, the technical community, international organizations, and the Brazilian government, representing a space for social dialogue and proposing public policies. On that occasion, the Brazilian Artificial Intelligence Plan (PBIA) was launched,[4] which, under the coordination of the MCTI, aims to realize the Brazilian project of technological autonomy, increasing the competitiveness of the national economy, and stimulating the responsible use of AI. As one of their contributions to the issue, NIC.br and CGI.br organized the 1st Seminar of the Brazilian Artificial Intelligence Observatory (OBIA),[5] an integral part of the PBIA, which plays an essential role in producing and disseminating data and studies on the adoption and use of AI-based systems in the country.

To support these debates and monitor the achievement of the commitments made, the availability of data and indicators is essential to map the socioeconomic implications of the adoption of digital technologies by different sectors of society. With two decades of regular production of reliable and internationally comparable statistical data, as well as dissemination of studies and analyses on the impacts of digital technologies on society, Cetic.br|NIC.br has many reasons to celebrate. Its commitment to excellence and methodological rigor in the production of quality data has ensured recognition and influence among public policymakers and international organizations linked to the ecosystem of indicators and statistics. In addition, Cetic.br|NIC.br maintains ongoing cooperation with civil society, the academic community, national statistical offices, and important international organizations such as the Organisation for Economic Co-operation and Development (OECD), the International Telecommunication Union (ITU), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Conference on Trade and Development (UNCTAD), the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and the United Nations Statistics Division (UNSD).

In this context, and in celebration of the 20th anniversary of Cetic.br|NIC.br, this publication offers valuable inputs for building accessible, relevant, and qualified knowledge, which is essential for informing debates and decisions on the country's digital transformation. Through the production of data and evidence as fundamental pillars, we seek not only to understand the challenges of the present, but also to pave the way for a more equitable and secure future for the next generations.

Renata Vicentini Mielli
Brazilian Internet Steering Committee – CGI.br

[4] More information about PBIA is available at https://www.gov.br/lncc/pt-br/assuntos/noticias/ultimas-noticias-1/plano-brasileiro-de-inteligencia-artificial-pbia-2024-2028

[5] OBIA can be accessed at https://obia.nic.br/

Executive Summary

ICT IN HEALTH SURVEY
2024

Executive Summary ICT in Health 2024

The ICT in Health survey, carried out since 2013, investigates the adoption and use of information and communication technologies (ICT) in Brazilian healthcare facilities. In its 11th edition, it presents data collected from managers and professionals in healthcare facilities (physicians and nurses), highlighting unprecedented indicators on training in health informatics, the use of generative Artificial Intelligence (AI), and the provision of electronic devices by facilities. Among the main results are the universalization of Internet access in healthcare facilities and by physicians and nurses, progress in the use of electronic devices, the adoption of electronic systems, and telehealth services. However, the use of AI is still limited, with adoption restricted to a few facilities and a small number of professionals.

More details on the results of this edition can be found in the survey's "Analysis of Results".

ICT INFRASTRUCTURE

Digitization in the health sector advanced in 2024. Internet and computer access was universalized in healthcare facilities. Compared to 2023, the main increases were in the country's public facilities (96% to 99%) and those in the North region (90% to 99%).

Physicians and nurses also now have universal access to the Internet and devices in the facilities where they work. The provision of portable devices such as laptops, tablets, and mobile phones was present in 75% of facilities, with a higher prevalence among private ones, those in the Northeast and Southeast regions, and inpatient facilities with more than 50 beds (about 8 out of 10). A new indicator showed the origin of the mobile equipment used by professionals. A higher percentage of nurses used the facilities' portable equipment—79% for laptops, 71% for tablets, and 26% for mobile phones—compared to physicians—60% for laptops, 24% for tablets, and 10% for mobile phones.

> 99% OF PHU HAVE ACCESS TO COMPUTERS AND THE INTERNET

ELECTRONIC HEALTH SYSTEMS

The adoption of electronic patient information systems has also increased in the period. As shown in Chart 1, 92% of healthcare facilities in 2024 had some kind of electronic system (compared to 87% in 2023). The growth occurred mainly in public facilities (85% in 2023 to 90% in 2024), private facilities (90% to 93%), outpatient facilities (87% to 92%) and Primary Health Units (PHU) (89% to 97%).

This computerization is reflected in the work of healthcare professionals, indicating more frequent access to patient data in electronic format, since more than half of them always consulted a large part of the data electronically. Among physicians, more than 70% always consulted information about the main reasons that led the patient to the medical service or appointment, patients' diagnoses, health problems or conditions, and lab test results. Among nurses, the most accessed data was diagnoses, health problems or conditions, the main reasons that led the patient to the medical service or appointment, and nursing notes.

TELEHEALTH

The ICT in Health survey monitors the adoption of telehealth in facilities and its use by professionals. In 2024, 30% of facilities offered teleconsulting services, which were more common in public units (38%) than in private ones (23%). Teleconsultation was present in 23% of facilities, with little variation between administrative jurisdictions. Telediagnosis services were offered in 23% of facilities and were slightly more common in private ones. Distance learning in health was made available by 20% of facilities (28% public and 13% private), while telemonitoring, offered by 16% of facilities, increased in public ones (from 19% to 24%). Teleconsultation services were most commonly offered by PHU (25%) and outpatient facilities (26%).

With regard to access to telehealth services by healthcare professionals, the results showed that distance education played an important role in the training and qualification of nurses and physicians, and that telediagnosis is a tool that has been gaining ground in their work. Chart 2 shows the frequency of use of telehealth services by professionals, indicating that constant use (always) is still low.

40% OF MANAGERS TOOK A COURSE IN HEALTH INFORMATICS

CAPACITY-BUILDING AND TRAINING OF MANAGERS AND PROFESSIONALS IN HEALTH INFORMATICS

In view of the growing digitization of health, the ICT in Health 2024 survey delved deeper into the training of managers and professionals in the area of health informatics. In the 12 months prior to the survey, around half of the managers underwent some training in the area, of which 37% underwent training or capacity building, 10% took specialization courses, 1% obtained master's degrees, and 3% took part in other types of training.

Among the managers of public facilities, 41% underwent training or capacity building in health informatics, compared to 33% of those in private facilities. The main topics covered included the organization of health services (67%), interdisciplinary team management (65%), resource (53%) and risk (52%) management, and health policies and regulatory frameworks (49%). More technical subjects, such as network architectures (26%) and business alignment (23%), were less explored.

As for professionals in the field, 23% of physicians and nurses were trained in health informatics in 2024. Among nurses, participation was higher in the private sector (26%) than in the public sector (21%), while among physicians, training was more common among those working in the public sector (29%) compared to the private sector (19%).

The topics most frequently covered by nurses included patient safety, person-centered care, ethics, security, and privacy, which were studied by around 80% of the professionals. Precision medicine (17%) and AI (20%) were the least explored topics. Among physicians, the most frequent topics were patient safety (95%), ethics, security, and privacy (85%), and data and information analysis (84%). Even though they were less mentioned, AI (48%) and precision medicine (35%) were more popular among physicians than among nurses. Training in health informatics is essential for the adoption of new technologies, and a significant proportion of managers and professionals sought training in this area.

The results of the ICT in Health 2024 survey indicated advances in the computerization of healthcare facilities and the work of professionals. However, many challenges remain, especially when it comes to expanding the use of AI and universalizing digital health training. The results of this edition reinforce the importance of drawing up public policies and making continuous investments to consolidate the digital transformation in the sector.

CHART 1

–

Healthcare facilities by availability of electronic systems to record patient information (2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)

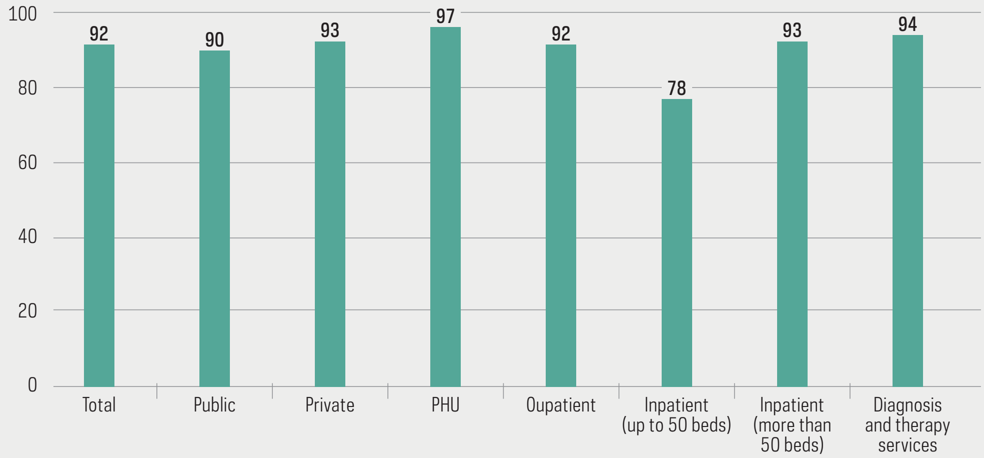

CHART 2

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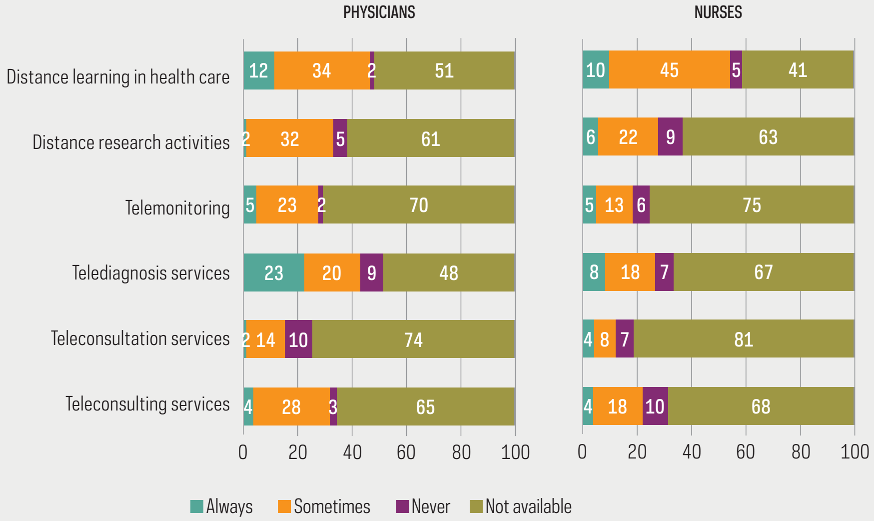
Physicians and nurses by how often they used telehealth services (2024)

Total number of physicians and nurses with computer access in the healthcare facilities (%)



Survey methodology and access to data

The eleventh edition of the ICT in Health survey collected data about healthcare facilities and professionals (physicians and nurses). Data was collected using telephone interviews and a web questionnaire with 2,057 managers and 2,021 professionals between February and August 2024. The results of the survey, including the tables of estimates, totals, and margins of error, are available on the website of the Regional Center for Studies on the Development of the Information Society (Cetic.br)—http://www.cetic.br. The methodological and data collection reports are available in both book format and on the website.

BOX 1

—

AI IN HEALTH

The use of AI in Brazilian healthcare facilities is still limited, being present in only 4%. Adoption was higher in inpatient facilities with more than 50 beds (16%) and in those with diagnosis and therapy services (SADT) (7%). In addition, the use of AI was higher in private facilities (6%) compared to public ones (1%).

For the first time, the survey investigated the appropriation of generative AI by healthcare professionals, indicating that 17% of physicians and 16% of nurses used it at work (Charts 3 and 4). Use varied according to administrative jurisdiction, and was more frequent in the private sector. Among physicians, 20% in the private sector and 14% in the public sector reported having used generative AI. For nurses, the difference was 15 percentage points, with 26% of private sector nurses and 11% of public sector nurses having used generative AI.

In terms of age group, for physicians, the highest uptake was among those 36 to 50 years old (29%), while among nurses, the highest adherence was among professionals 41 years old or older (21%). Among physicians and nurses who used generative AI, the primary use was for research, as shown in Chart 5.

CHART 3

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Physicians by use of generative AI resources (2024)

Total number of physicians with computer access in the healthcare facilities (%)

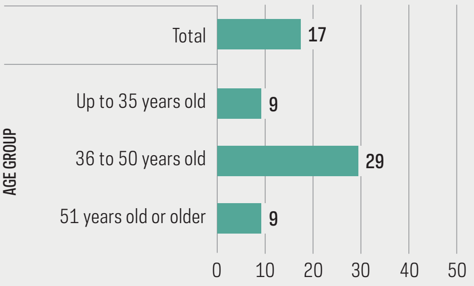
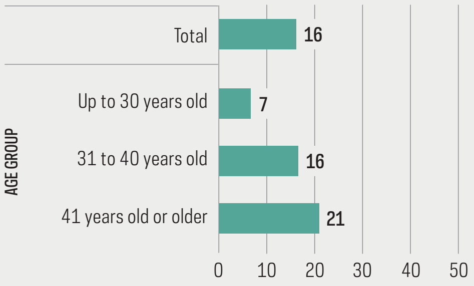


CHART 4

—

Nurses by use of generative AI resources (2024)

Total number of nurses with computer access in the healthcare facilities (%)



4%
of healthcare facilities used AI

16%
inpatient facilities with more than 50 beds used AI

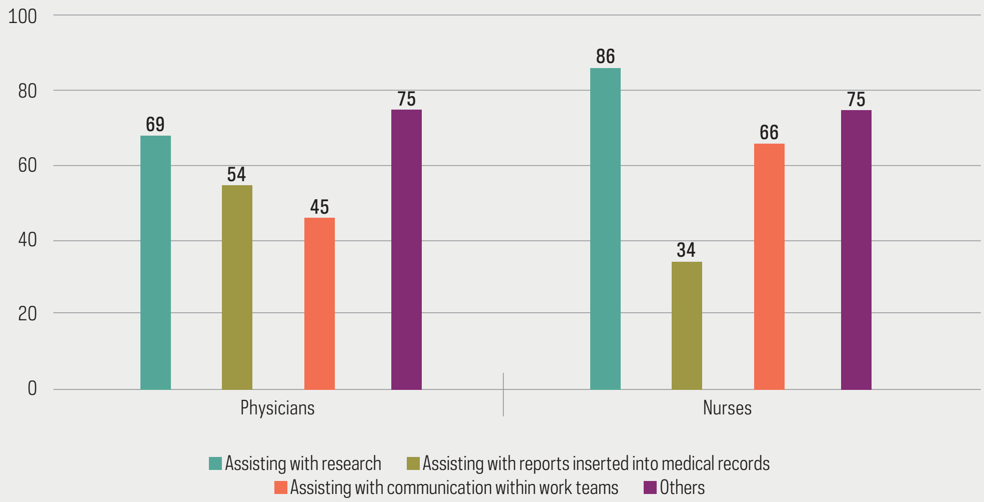
7%
of SADT used AI

CHART 5

—

Physicians and nurses by types of use of generative AI (2024)

Total number of physicians and nurses with computer access in the healthcare facilities (%)



Access the full survey data!

In addition to the results presented in this publication, tables of indicators, questionnaires, information on how to access the microdata, and the presentation of the results of the launch event are available on the Cetic.br|NIC.br website, as well as other publications on the topic of the survey.

The tables of results (https://cetic.br/en/pesquisa/saude/indicadores/), available for download in Portuguese, English, and Spanish, present the statistics produced, including information on the data collected and cross-referencing for the variables investigated in the study. The information available in the tables follows the example below:

Code and indicator name

Population to which the results refer

B0 - HEALTHCARE FACILITIES BY AVAILABILITY OF AN ELECTRONIC SYSTEM TO RECORD PATIENT INFORMATION

Total number of healthcare facilities that used the Internet in the last 12 months

Indicator responses

PERCENTAGE (%)		YES	NO	DOES NOT KNOW	DID NOT ANSWER	DOES NOT APPLY
TOTAL		92	8	0	0	1
ADMINISTRATIVE JURISDICTION	Public	90	9	0	0	0
	Private	93	7	0	0	1
REGION	North	89	10	0	0	1
	Northeast	89	11	0	0	1
	Southeast	93	6	0	0	0
	South	94	5	0	0	0
	Center-West	90	9	0	0	1
TYPE OF FACILITY	Outpatient	92	7	0	0	0
	Inpatient (up to 50 beds)	78	22	0	0	0
	Inpatient (more than 50 beds)	93	7	0	0	0
	Diagnosis and therapy services	94	4	0	0	1

Results tabulation cut-outs: total (population as a whole) and characteristics of analysis (region, age group, etc.), different in each survey

Results: can be in % or totals

Source: Brazilian Network Information Center. (2024). *Survey on the use of information and communication technologies in Brazilian healthcare facilities: ICT in Health 2024* [Tables].

How to reference the tables of indicators

This publication is also available in Portuguese on the Cetic.br|NIC.br website.

Methodological Report

ICT IN HEALTH SURVEY
2024

Methodological Report
ICT in Health 2024

The Brazilian Internet Steering Committee (CGI.br), through the Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of the Brazilian Network Information Center (NIC.br), presents the "Methodological Report" of the Survey on the use of information and communication technologies in Brazilian healthcare facilities—ICT in Health. The study was carried out across the country, addressing subjects related to ICT penetration in healthcare facilities and its appropriation by healthcare professionals.

The data obtained through the survey seeks to contribute to the formulation of public policies specific to the health sector by generating input for public managers, healthcare facilities, healthcare professionals, academia and civil society. The survey relied on the support of international organizations such as the Organisation for Economic Co-operation and Development (OECD), Economic Commission for Latin America and the Caribbean (ECLAC), and United Nations Educational, Scientific and Cultural Organization (UNESCO), as well as national entities such as the Brazilian Ministry of Health, through the Department of Informatics of the Brazilian Public Health System (Datasus) and the National Regulatory Agency for Private Health Insurance and Plans (ANS), in addition to government and civil society representatives and specialists attached to renowned universities.

The ICT in Health survey is an initiative that incorporates the model developed by the OECD for statistics in the sector. The guide created by that organization, the *OECD Guide to Measuring ICTs in the Health Sector*:

> has been developed with the aim to provide a standard reference for statisticians, analysts and policy makers in the field of health Information and Communication Technologies (ICT). The objective is to facilitate cross-country data collection, comparisons and learning on the availability and use of health ICTs. (OECD, 2015, p. 2)

In 2021 the survey sample was reformulated to facilitate the production of estimates disaggregated by federative unit. To enable the generation of this information, the survey sample included a larger number of facilities to be reached over the span of two editions. In the first year, the plan was to include an expanded sample of healthcare facilities without the corresponding data collection from healthcare professionals. In the second year, data collection will be carried out with a small sample of healthcare facilities, followed by interviews with professionals. The combined estimates of the two years will be used to provide readings per federative unit for healthcare facilities.

Survey objectives

The overall goal of the ICT in Health survey is to understand the stage of ICT adoption in Brazilian healthcare facilities and their appropriation by healthcare professionals. Within this context, the survey has the following specific objectives:

I. ICT PENETRATION IN HEALTHCARE FACILITIES

- identify the ICT infrastructure available in Brazilian healthcare facilities;
- investigate the use of ICT-based systems and applications to support care services and management of facilities.

II. ICT APPROPRIATION BY HEALTHCARE PROFESSIONALS

- investigate the ICT skills of professionals and the activities carried by them with the use of ICT;
- understand the motivations and barriers related to the adoption of ICT and its use by healthcare professionals.

Concepts and definitions

HEALTHCARE FACILITIES

According to the definition adopted by the National Registry of Healthcare Facilities (CNES), maintained by the Datasus, healthcare facilities can be broadly defined as all locations designated for the provision of collective or individual healthcare actions and services, regardless of their size or level of complexity. With the goal of focusing on institutions that operate with infrastructure and physical facilities devoted exclusively to healthcare activities, the survey was also based on definitions from the 2009 Survey of Medical-Sanitary Assistance (AMS) of the Brazilian Institute of Geography and Statistics (IBGE). The AMS survey encompassed all the healthcare institutions in the country that provided individual or collective, public or private, and for-profit or nonprofit health care, with a minimum level of required expertise, according to the criteria established by the Brazilian Ministry of Health for routine outpatient or inpatient care. This universe included health units, health centers, clinics and medical assistance units, emergency departments, mixed units, hospitals (including those of military organizations), complementary diagnosis and/or therapy units, dental, radiology and rehabilitation clinics, and clinical analysis laboratories (IBGE, 2010).

HEALTHCARE PROFESSIONALS

The ICT in Health survey takes into account the information adopted by the CNES to identify the healthcare professionals analyzed in this study. These professionals work in healthcare facilities providing care to patients within or outside the Unified Health System (SUS, or *Sistema Único de Saúde*, in Portuguese). The identification of physicians and nurses is based on the Brazilian Occupational Classification (CBO) maintained by the Federal Government.

ADMINISTRATIVE JURISDICTION

According to the classification given by CNES, the ICT in Health survey considered public facilities to be those administered by federal, state or municipal governments. The remaining facilities (for-profit or nonprofit) were considered private.

BEDS FOR INPATIENTS

Specific physical facilities for receiving patients staying for a minimum of 24 hours. Day hospitals were not considered inpatient care units.

TYPE OF FACILITY

This classification was assigned according to a combination of characteristics of the facilities, related to the type of care provided and number of inpatient beds. The reference for this classification was the same as the one adopted by IBGE's AMS survey. Thus, four mutually exclusive groups of facilities were established:

- **outpatient**: facilities that do not admit patients (with no beds) and provide other types of care (emergency, outpatient, etc.);
- **inpatient (up to 50 beds)**: facilities that admit patients and have from one to 50 beds;
- **inpatient (more than 50 beds)**: facilities that admit patients and have 51 beds or more;
- **diagnosis and therapy services (SADT)**: facilities that do not offer inpatient care (with no beds) and are devoted exclusively to diagnosis and therapy services, defined as units where the activities that take place help determine diagnoses and/or complement patient treatment and rehabilitation, such as labs.

TYPE OF UNIT

Based on the classification of the type of facility assigned by the CNES, the ICT in Health survey used the following classification:

- health units;
- health centers/basic units;
- polyclinics;

- general hospitals;
- specialty clinics/centers;
- isolated SADT;
- psychosocial care centers;
- emergency units;
- other types of aggregated units.

PRIMARY HEALTHCARE UNITS (PHU)[1]

Refers to active PHU in the CNES of the following types of facilities: health units; health centers/basic units; mixed service units; family health support centers. For mixed service units, only units with family health teams were considered in the variable "types of teams" in the survey basis.

TARGET POPULATION

The target population of the survey was made up of Brazilian healthcare facilities. For the purposes of research and surveying of the reference population, facilities registered with the CNES were considered. Thus, the scope of the survey included public and private healthcare facilities registered with the CNES that had their own registration numbers from the National Registry of Legal Entities (CNPJ) or that of a supporting entity, as well as physical facilities designated exclusively for healthcare-related activities, with at least one physician or nurse. Therefore, the following facilities were not considered in the survey:

- facilities registered as natural persons;
- isolated offices, defined as isolated spaces used for providing medical or dental care, or services of other healthcare professionals with tertiary education;
- isolated home care services (home care) or residential services;
- orthopedic clinics;
- facilities created on a temporary basis or for campaigns;
- mobile units (pre-hospital level emergency care, terrestrial, aerial or fluvial);
- pharmacies;
- facilities without at least one physician or nurse on staff, except for facilities classified as SADT but where there is at least one employee;

[1] Mobile units were not considered in the target population of the survey and were removed from the primary healthcare units, as was the case in other strata.

- facilities dedicated to administration of the system, such as health secretariats, regulatory and health surveillance agencies and other organizations with these characteristics, currently registered with the CNES.

Each facility was treated as a conglomerate made up of professionals in administrative positions—managers responsible for providing information about the facilities—and healthcare professionals—physicians and nurses—who are the survey target population.

REFERENCE AND ANALYSIS UNIT

To achieve the objectives of the survey, healthcare facilities and professionals were considered to be analysis units. As established in the reformulation of the survey, in some years only facilities will be surveyed, and in subsequent years both facilities and healthcare professionals will.

DOMAINS OF INTEREST FOR ANALYSIS AND DISSEMINATION

In this edition of the survey, data was only collected for healthcare facility analysis units and the results are presented for domains defined according to the following variables and levels:

- **administrative jurisdiction:** corresponds to the classification of institutions as public or private;
- **type of facility:** this classification is associated with four different types of facilities, based on the type of care and size, in terms of beds—outpatient, inpatient (up to 50 beds), inpatient (more than 50 beds) and SADT;
- **region:** corresponds to the division of Brazil into macro-regions (North, Center-West, Northeast, Southeast, and South), according to IBGE criteria;
- **location:** refers to whether a facility is located in a capital or in noncapital cities of each federative unit;
- **PHU identification**: refers to the PHU and Not a PHU classifications;
- **federative unit:** corresponds to the classification of the healthcare facility according to the federative unit where it is located, considering all 26 states and the Federal District. The UF, however, is only publicised in the years when the survey is carried out only with managers of healthcare establishments.

Regarding the units of analysis healthcare professionals (physicians and nurses), the following characteristics obtained from the information provided by the respondents were added to the above domains, with the exception of UF:

- **age group:** refers to the age of the professional divided into three ranges, depending on the sample group:
  - for nurses: up to 30 years old; 31 to 40 years old; and 41 years old and over;
  - for physicians: up to 35 years old; 36 to 50 years old; and 51 years old and over.

Data collection instruments

INFORMATION ON THE DATA COLLECTION INSTRUMENTS

The information of interest to this edition of the survey was collected through two structured questionnaires with closed and open questions (when necessary). One was administered to administrative professionals in the facilities (preferably information technology [IT] managers) and the other to healthcare professionals (physicians and nurses). For more information about the questionnaires, see the "Data collection method" section in the "Data Collection Report".

Sampling plan

The design of the ICT in Health sampling plan was based on a stratified simple sampling (Cochran, 1977) of healthcare facilities, in which stratification considers the following variables: federative unit (27 classes), administrative jurisdiction (public or private), and type of facility (PHU, outpatient, inpatient with up to 50 beds, inpatient with more than 50 beds, and SADT).

SURVEY FRAME AND SOURCES OF INFORMATION

The survey frame used for selecting the healthcare facilities was the CNES maintained by Datasus, of the Ministry of Health. Established by Ordinance MS/SAS No. 376/2000, the CNES contains the registries of all healthcare facilities (inpatient and outpatient) that make up the public and private health systems in the country. The CNES keeps databases at the local and federal levels up to date, to assist managers with implementing health policies.

The registries are used to support areas involving planning, regulation, evaluation, control, auditing, teaching and research (Brazilian Ministry of Health, 2006).

SAMPLE DESIGN CRITERIA

Previous editions of the ICT in Health survey used stratified sampling of facilities with probability proportional to a size measure (number of employees). This method was used to ensure the presence of a pool of health professionals who would respond on behalf of the other two target audiences that were of interest for the survey. Because the methodology for selecting the professionals was redesigned in view of the difficulties with conducting interviews with this audience, the use of a sample design based on probability proportional to size (PPS) was considered unnecessary.

In addition, since most of the parameters of interest that the survey sought to estimate were proportions and counts by domains, PPS was not expected to improve their accuracy. Therefore, the healthcare facilities were submitted to simple stratified sampling, i.e., they were selected using simple random sampling without replacement within the defined strata.

SAMPLE SIZE DETERMINATION

The sample size for the two years of the ICT in Health survey was set at approximately 15.000 facilities. An important aspect to consider is the rate of sampling loss due to the nonresponse of facilities. Details about sample size determination for this edition are presented in the survey's "Data Collection Report."

SAMPLE ALLOCATION

Since one of the goals of the survey was to present the results separately for the domains defined for the variables, i.e., type of facility, federative unit, location, and administrative jurisdiction, the sample allocation was defined according to the classification of the facilities within these variables. Thus, the chosen stratification defined the strata by cross-classifying three variables: federative unit, type of administrative jurisdiction (with two categories: public and private), and type of facility (with 5 categories: PHU, outpatient, inpatient with up to 50 beds, inpatient with more than 50 beds, and SADT).

This stratification was initially implemented in the form of a two-dimensional table: 27 federative units in the rows, and the valid combinations of type of facility and administrative jurisdiction in the columns. This idea allowed for the application of a sample allocation technique in the final strata that ensured the desired sample sizes in the two dimensions of the table. This specific method is called iterative proportional fitting (Deming & Stephan, 1940).

To allocate the sample among the federative units, power allocation was used (Bankier, 1988) with the use of ½ power. To allocate the sample among the classes of type of facility x type of administrative jurisdiction, power allocation with power equal to ½ was employed. Once the margin allocation of the two-dimensional tables was defined, the iterative proportional fitting algorithm was applied (Deming & Stephan, 1940) using the *ipf* function of the humanleague package of R statistics software (Smith, 2018).

The resulting sample sizes were rounded to the nearest integer, and then all sizes were increased to a minimum of three (when there was this quantity in the universe of facilities). This adjustment was necessary to ensure that the expected effective sample size per stratum was equal to or greater than two.

Based on these considerations, the desired sample sizes were established, also adjusting for nonresponse rates, so that the survey could provide results within the margin of error specified by federative unit and other variables of interest. The sample size for the defined margins can be found in the "Data Collection Report".

For the selection of healthcare professionals—physicians and nurses—the specific nature of healthcare facilities (the target of the survey) is considered. Healthcare facilities in the ICT in Health survey are divided into two groups:

- **Group 1**, in which 1 (one) physician and 1 (one) nurse were interviewed in the healthcare facilities classified as "PHU" and "outpatient"; and
- **Group 2**, in which 2 (two) physicians and 2 (two) nurses were interviewed in the healthcare facilities classified as "inpatient up to 50 beds" and "inpatient more than 50 beds."

In **Group 1**, at the end of the interview with the manager, we sought to interview healthcare professionals promptly. For facilities where there was no need for a department draw, the interviewed manager was asked to transfer the call to the physicians and nurses who were at the facility at that moment. For facilities with more than one department and more than 20 physicians or more than 10 nurses on their staff, the department draw was maintained, and at the end of the interview, the manager was asked to transfer the call to the physicians and nurses who were in the drawn department(s) at that moment. If the call transfer was not possible, the direct phone number of the selected department(s) was requested and recorded. If no direct phone number was available, attempts to contact the professionals for the interviews were made using the telephone number of the facility.

In **Group 2**, when there was a department draw, that is, for cases in which there was more than one department in the facility and more than 20 physicians or more than 10 nurses on the staff, at the end of the interview with the manager, the telephone number of the drawn department(s) was requested and recorded, and in cases where there was no need for a draw, the interviewer team contacted the physicians and nurses of the facility to conduct the interviews.

SAMPLE SELECTION

HEALTHCARE FACILITIES

Within each stratum, healthcare facilities were selected using simple random sampling. Thus, the sample size in each stratum is determined by Formula 1.

FORMULA 1

$$n_h = n \times \frac{N_h}{N}$$

N is the size of the total population

N_h is the size of stratum population h

n is the sample size

n_h is the sample size within each stratum h

Thus, the probability of including (π) healthcare facility i for each stratum h is given by Formula 2.

FORMULA 2

$$\pi_{ih} = \frac{n_h}{N_h}$$

Field data collection

DATA COLLECTION METHOD

All healthcare facilities were contacted by telephone and data collection was conducted with those responsible for the facilities (preferably IT managers) and healthcare professionals (physicians and nurses) using the computer-assisted telephone interview (CATI) technique. There was a self-administered web version of the questionnaire that could be accessed via a specific platform. This option was given only to the respondents who spontaneously asked to respond via the Internet or those who promptly refused to answer the survey on the telephone.

Respondents who opted for this modality were sent a link specific to their questionnaire, which allowed them to change their answers. Whenever possible, the team sought to interview the managers responsible for IT departments or, if these professionals did not exist, the administrative managers.

Data processing

HEALTHCARE FACILITIES WEIGHTING PROCEDURES

The survey weighting was based on the calculation of the basic weights derived from the selection probability in each stage, which were adjusted for nonresponse. The weights for each healthcare facility were calibrated for the known totals of the survey's target population.

BASIC WEIGHT

Each healthcare facility in the sample was associated with a basic sample weight, expressed as the ratio of the population size to the sample size of the corresponding final stratum. Basic weights were calculated as the inverse probability of selecting the facility in each stratum, expressed by Formula 3.

FORMULA 3

$$w_{ih} = \frac{1}{\pi_{ih}} = \frac{N_h}{n_h}$$

w_{ih} is the basic weight for facility i in stratum h

N_h is the total number of facilities in stratum h

n_h is the total sample of facilities in stratum h

CORRECTION FOR NONRESPONSE

To correct for nonresponse, adjustment was carried out using a logistic model to predict the probability of response—when many strata do not have a responding facility—or by simple correction in each survey stratum.

MODEL ADJUSTMENT

The model was based on the following variables: region, location, administrative jurisdiction, type of facility, connection to the Internet according to CNES registry, presence of contact information in the registry, size of facility in terms of number of employees, groups of federative units by response rate to the survey and belonging to the Brazilian Company of Hospital Services (EBSERH) database of university hospitals. The result of the model was the estimated response probabilities for each of the survey's responding facilities. Thus, nonresponse was corrected using Formula 4.

FORMULA 4

$$w_{ih}^{*} = w_{ih} \times \frac{1}{p_r}$$

w_{ih}^{*} is the weight adjusted for the nonresponse of facility i in stratum h

p_r is the probability of the facility responding according to logistic model

NONRESPONSE ADJUSTMENT BY STRATUM

Nonresponse adjustment by stratum was obtained using Formula 5.

FORMULA 5

$$w_{ih}^{*} = w_{ih} \times \frac{\sum_{i}^{nh} w_{ih}}{\sum_{I}^{nh} w_{ih} \times I_{ih}}$$

w_{ih}^{*} is the weight adjusted for the nonresponse of facility i in stratum h

I_{ih} is an indicator variable that receives a value of 1 if unit i in stratum h answered the survey and 0, otherwise

CALIBRATION

At the end, the weights adjusted for nonresponse were post-stratified for the stratification variables whose results are disseminated. Furthermore, the variable that identifies whether the facility belongs to the EBSERH network and the registry information on Internet access were also considered. Thus, using these variables, the total values of the sample were added to the total values in the registry. Post-stratification was carried out by multiplying the corrected weight for non-response w^* in each stratum by a factor that adjusts the total stratum (sum of weights with nonresponse correction) to the total population. This method is known as iterative proportional fitting, also known as incomplete multivariate post-stratification or raking. The final weight of the facilities was: w_{ih}^{*C}.

PROFESSIONALS WEIGHTING PROCEDURES

The survey weighting for the responding healthcare professionals started from the final weight established for the facilities in the survey. The calculation of basic weights for professionals is determined by multiplying the final weights of facilities and the inverse of the probability of selecting a professional in each facility. Based on this weight, nonresponse corrections and calibration were performed for the known totals of the survey's target population.

BASIC WEIGHT

Each healthcare professional in the sample is assigned a basic sample weight, obtained by multiplying the final weight of the facility for which the professional is a respondent and the ratio between the population size of professionals and the corresponding sample size of respondents. The basic weight is expressed by Formula 6.

FORMULA 6

$$v_{jih} = w^{*c}_{ih} \times \frac{M_{ih}}{m_{ih}}$$

v_{jih} is the basic weight of professional j of facility i in stratum h

M_{ih} is the total number of professionals in facility i in stratum h

m_{ih} is the total number of responding professionals in facility i in stratum h

NONRESPONSE CORRECTION

To correct for the cases in which no response from professionals was obtained for all facilities in some strata, an adjustment was made by means of a logistic model to predict the probability of response—when many strata do not have a responding facility.

In case a response from professionals was obtained for facilities in all strata of the survey, nonresponse correction was performed per stratum without using the model.

MODEL ADJUSTMENT

The logistic model is based on the variables region, location, administrative jurisdiction, type of facility, Internet connection according to the CNES registry, existence of contact information in the registry, size class in number of employees, federative unit groups according to the survey response rate and belonging to the university hospitals' database of EBSERH. The results of the model are the estimated probabilities of response for each of the facilities participating the survey. Nonresponse is then corrected by Formula 7.

FORMULA 7

$$v^{*}_{jih} = v_{jih} \times \frac{1}{p_r}$$

v^{*}_{jih} is the weight adjusted for nonresponse from professionals of facility i in stratum h

p_r is the probability of responses from professionals in facility i in stratum h second logistic model

NONRESPONSE ADJUSTMENT BY STRATUM

Nonresponse adjustment by stratum was obtained using Formula 8.

FORMULA 8

$$v^{*}_{jih} = v_{jih} \times \frac{n_h}{\Sigma^{nh}_{i} J_{ih}}$$

v^{*}_{jih} is the weight adjusted for nonresponse from professionals of facility i in stratum h

J_{ih} is an indicator variable that receives a value of 1 if facility i in stratum h had responding professionals, and 0, otherwise

CALIBRATION

At the end, the weights of professionals adjusted for nonresponse were post-stratified for the stratification variables, whose results are disseminated. Furthermore, the variable indicating whether the facilities belong to the EBSERH network was also taken into account, as well as the total number of professionals listed in the register when selecting the sample. Thus, using these variables, the total values of the sample were added to the total values in the registry. Post-stratification was carried out by multiplying the corrected weight for non-response v^* in each stratum by a factor that adjusts the total stratum (sum of weights with nonresponse correction) to the total population. This method is known as iterative proportional fitting, also known as incomplete multivariate post-stratification or raking. The final weight of the facilities was: v_{jih}^{*C}.

SAMPLING ERRORS

The measurements or estimates of sampling error in the indicators of the ICT in Health survey took into consideration in its calculations the sampling plan by strata used in the survey.

The ultimate cluster method was used to estimate variances for total estimators in multi-stage sampling plans. Proposed by Hansen et al. (1953), this method considers only the variation between information available at the level of primary sample units and assumes that these have been selected with replacement.

Based on this method, it is possible to consider stratification and selection with unequal probabilities, for both primary sample units and other sample units. The assumptions that permit the application of this method are that unbiased estimators are available for the totals of the variables of interest for each of the selected ultimate clusters, and that at least two of these estimators are selected in each stratum (if the sample was stratified in the first stage).

This method provides the basis for several statistical packages that specialize in calculating variances, based on the sampling plan.

Based on the estimated variances, the option was chosen to publish the sampling errors expressed by the margins of error. For publication, these margins were calculated for a confidence level of 95%. This means that if the survey were to be repeated, the range would contain the actual population value 19 out of 20 times.

Other measures derived from this variability estimate are commonly presented, such as standard error, coefficient of variation and confidence interval.

Margins of error were calculated by multiplying the standard error (square root of the variance) by 1.96 (sample distribution value, which corresponds to the chosen significance level of 95%). These calculations were done for each variable in all the tables. Hence, all indicator tables had margins of error related to each estimate presented in each cell of the table.

Data dissemination

The results of this survey are presented according to the following domains of analysis: administrative jurisdiction, region, type of facility, PHU identification, location and Federative Unit for information about the healthcare facilities, in addition to the variable age group for information about health professionals.

Rounding made it so that in some results, the sum of the partial categories differed from 100% for single-answer questions. The sum of frequencies on multiple-answer questions is usually different from 100%. It is worth noting that, in cases with no response to the item, a hyphen was used. Since the results are presented without decimal places, a cell's content is zero whenever an answer was given to that item, but the result for this cell is greater than zero and smaller than one.

The results of the ICT in Health survey are published in printed format and online and made available on the website of Cetic.br|NIC.br (http://www.cetic.br). The tables of totals and margins of error calculated for each indicator are available for download on the same page.

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Data Collection Report

ICT IN HEALTH SURVEY
2024

Data Collection Report
ICT in Health 2024

The Brazilian Internet Steering Committee (CGI.br), through the Regional Center for Studies on the Development of the Information Society (Cetic.br), of the Brazilian Network Information Center (NIC.br), presents the "Data Collection Report" of the 2024 ICT in Health survey. The objective of this report is to provide information about specific characteristics of the 2024 survey, including changes made to data collection instruments, sample allocation implemented this year, and response rates.

The complete survey methodology, including the objectives, main concepts and definitions, and characteristics of the sampling plan, are described in the "Methodological Report".

Sample allocation

To collect data from facilities and professionals, 7.757 facilities were selected to participate in the survey. Table 1 presents the sample allocation of healthcare facilities.

TABLE 1

Sample allocation of healthcare facilities by administrative jurisdiction, type of facility, and federative unit

		Planned sample
Administrative jurisdiction	Public	3 592
	Private	4 165

CONTINUES ▶

▶ CONCLUSION

		Planned sample
Type of facility	Outpatient	5 090
	Inpatient (up to 50 beds)	790
	Inpatient (more than 50 beds)	541
	Diagnosis and therapy services (SADT)	1 336
Federative unit	Rondônia	124
	Acre	90
	Amazonas	197
	Roraima	80
	Pará	261
	Amapá	74
	Tocantins	212
	Maranhão	468
	Piauí	237
	Ceará	326
	Rio Grande do Norte	233
	Paraíba	311
	Pernambuco	327
	Alagoas	221
	Sergipe	176
	Bahia	455
	Minas Gerais	519
	Espírito Santo	207
	Rio de Janeiro	527
	São Paulo	738
	Paraná	347
	Santa Catarina	289
	Rio Grande do Sul	378
	Mato Grosso do Sul	160
	Mato Grosso	233
	Goiás	327
	Federal District	240

Data collection instruments

INFORMATION ON THE DATA COLLECTION INSTRUMENTS

The data was collected through two structured questionnaires, one that was applied to managers in the facilities (preferably information technology [IT] managers), and the other to healthcare professionals (physicians and nurses). Information on the healthcare facilities was obtained from professionals at the managerial level, whereas physicians and nurses answered questions about their work routines, according to the definitions set forth in the "Concepts and definitions" section of the "Methodological Report".

The questionnaire about the healthcare facilities contained information regarding information and communication technology (ICT) infrastructure, IT management, electronic health records, information exchange, online services provided to patients, telehealth and new technologies. The questionnaire targeting professionals investigated their profiles, in addition to ICT access, uses and appropriation.

CHANGES IN THE DATA COLLECTION INSTRUMENTS

Based on the results of the interviews conducted during the pretests, changes were made to the survey questionnaires. The main objective of the changes was to adapt them to standards under discussion in international forums for collection of data on the use of ICT in the health sector.

Other modifications were made to test new items relevant to understanding ICT access and use in the sector, and to enhance the collection of information.

The main changes in the questionnaire about the healthcare facilities were as follows:

Module A – Facility/respondent profile:

- inclusion of an indicator that investigates the topic(s) covered in health informatics training attended in the 12 months prior to the survey.

Module B – ICT infrastructure in the facility:

- inclusion of an indicator that investigates whether the healthcare facilities provided employed persons with mobile devices, such as laptops, tablets, or mobile phones, for work purposes;
- inclusion of the social networks "LinkedIn" and "X" as examples in the indicator that investigates whether the healthcare facilities have social network profiles or accounts.

Module C – Electronic health records and exchange of information:

- exclusion of the indicator that investigates whether electronic health records are printed;
- inclusion of an item that investigates whether the healthcare facilities have electronic systems that allow them to list all the patients' immunizations.

Module H – New technologies:

- inclusion of an item that investigates whether, in the 12 months prior to the survey, the healthcare facilities used ChatGPT, Bard/Gemini, among others, as an Artificial Intelligence (AI) tool;
- inclusion of a semi-open item to identify the reason(s) why the healthcare facilities did not use AI techniques in the 12 months prior to the survey.

Module G – Perceptions of managers:

- exclusion of the item that investigates the extent to which the managers of healthcare facilities agree or disagree that the facility's electronic systems allow for the exchange of information with other electronic systems.

The main changes in the questionnaire for healthcare professionals (physicians and nurses) in the healthcare facilities were as follows:

Module F – ICT access and use:

- inclusion of an indicator that investigates the origin of the equipment available for physicians' and nurses' professional or personal use in the healthcare facilities, whether it is owned by the facility or brought in by themselves;
- inclusion of an item that investigates whether the surgical procedures report is available electronically in the healthcare facilities and, if so, how often this information is accessed;
- inclusion of details on the type of biometrics used to access electronically available data—whether by facial or digital recognition.

Module G – ICT appropriation:

- inclusion of an indicator that investigates the topic(s) covered in health informatics training completed by health professionals in the 12 months prior to the survey;
- inclusion of an indicator that investigates whether the healthcare facilities' physicians and nurses use generative AI resources, such as ChatGPT and Bard/Gemini;
- inclusion of an indicator that investigates, among physicians and nurses, the use of resources such as ChatGPT, Bard/Gemini or others, and the purpose for using these technologies.

PRETESTS

Eight interviews were conducted with general or IT managers of healthcare facilities and five with healthcare professionals (three with nurses and two with physicians) between February 9 and 20, 2024, in different types of healthcare facilities. The aim was to test the adequacy and validity of the constructed questions and indicators, and measure the time required to administer the questionnaires.

INTERVIEWER TRAINING

The interviews were conducted by a team of trained and supervised interviewers, who underwent basic research training; organizational training; ongoing improvement training; and refresher training. They also underwent specific training for the 2024 ICT in Health survey, which included how to approach the responding audience, and information about the data collection instrument, procedures, and situations.

The data collection team also had access to the survey's instruction manual, which contains a description of all the necessary procedures to collect data and details about the survey objectives and methodology, ensuring the work standardization and quality.

Data collection for healthcare professionals and managers was performed by 52 interviewers and two supervisors.

Data collection procedures

DATA COLLECTION METHOD

The aim was to interview the main manager of the healthcare facility or a manager who was familiar with the organization as a whole, including both its administrative aspects and ICT infrastructure. In the 2024 ICT in Health survey, preference was given to IT managers, who answered questions about the healthcare facilities. In the healthcare facilities where interviews were conducted with managers, healthcare professionals (nurses and physicians) were also interviewed.

Healthcare facility managers and healthcare professionals were contacted using the computer-assisted telephone interviewing (CATI) technique. The same questionnaire was made available for self-completion via the Web for managers and health professionals who requested it.

DATA COLLECTION PERIOD

Data for the 2024 ICT in Health survey was collected from the sampled healthcare facilities between February and August 2024. The interviews with healthcare professionals and managers were carried out between 8 AM and 7 PM Brasilia time (UTC-3).

PROCEDURES AND CONTROLS

An automated system was established that enabled measuring and controlling the effort expended to obtain the interviews. It involved the treatment of situations identified during data collection.

Prior to the fieldwork, the list of phone numbers to be used to contact the facilities was reviewed and checked. The team tried contacting all the facilities selected in the sample and, whenever there was an incorrect or outdated number, they looked for a new contact number for the facility.

After the list was revised, the following procedures were carried out:

- Contacting the facilities and identifying the respondents. Whenever possible, the team sought to interview the managers responsible for IT departments or, if these professionals did not exist, the main managers responsible for the facilities. If it was impossible to interview the main persons responsible, managers capable of answering questions about general aspects of the facilities, such as administrative information, ICT infrastructure, and human resources, were identified. Professionals who did not hold management, coordination or supervisory positions were not considered.
- Several actions were taken to ensure the highest possible standardization in data collection. The standard situations adopted, as well as the number of cases recorded at the end of data collection, are described in Table 2. Each time an interviewer called a number in the survey frame, the situation corresponding to that call was recorded as per the described procedures, which could be followed up through the detailed call history.

TABLE 2

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Number of recorded cases, according to field situations

Situations		Total
Block 1	Could not speak with a representative of the healthcare facility	483
Block 2	Spoke with a representative of the healthcare facility or the respondent, but did not complete the interview	1 882
Block 3	Interview with the healthcare facility manager fully completed	2 057
Block 4	Definite impossibility of carrying out interview with the healthcare facility manager	2 710

DATA COLLECTION RESULTS

The survey response rate for facilities in 2022 was lower than that observed in 2023.

For the ICT in Health 2024 survey, interviews were conducted in 2,057 healthcare facilities, reaching 27% of the planned sample of 7,757 facilities. Among health professionals, 2,020 responded to the survey in 1,473 establishments that responded to the survey (78% response rate from professionals in establishments).The response rate of facilities by stratification variable is presented in Table 3.

TABLE 3

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Response rate of facilities by administrative jurisdiction, type of facility and federative unit

		Response rate
Administrative jurisdiction	Public	30%
	Private	24%
Type of facility	Outpatient	25%
	Inpatient (up to 50 beds)	36%
	Inpatient (more than 50 beds)	45%
	SADT	21%
Federative unit	Rondônia	27%
	Acre	19%
	Amazonas	11%
	Roraima	20%
	Pará	9%
	Amapá	18%
	Tocantins	23%
	Maranhão	8%
	Piauí	11%
	Ceará	19%
	Rio Grande do Norte	19%
	Paraíba	16%
	Pernambuco	20%
	Alagoas	12%
	Sergipe	23%
	Bahia	19%
	Minas Gerais	41%
	Espírito Santo	31%
	Rio de Janeiro	18%
	São Paulo	38%
	Paraná	48%
	Santa Catarina	52%

CONTINUES ▶

▶ CONCLUSION

		Response rate
Federative unit	Rio Grande do Sul	37%
	Mato Grosso do Sul	42%
	Mato Grosso	32%
	Goiás	32%
	Federal District	35%

Analysis of Results

ICT IN HEALTH SURVEY
2024

Analysis of Results
ICT in Health 2024

The transformative potential of information and communication technologies (ICT) in the healthcare sector has been increasingly recognized by public policymakers, managers, healthcare professionals, and patients. These technologies are redefining how users interact with healthcare systems, impacting efficiency, quality of care, and satisfaction with the services offered. However, they also bring challenges, such as the digital divide, problems integrating systems, concerns about the privacy of users and patients, and the need for constant technological updates (Hareem et al., 2024). Applications of digital technologies—such as electronic medical records, remote services, mobile solutions, and digitization of prescriptions—can have a significant impact on the way clinical practices are carried out, requiring the structuring of policies that promote their integration into health systems.

In recent years, Brazil has made significant progress in implementing digital health initiatives, with efforts aimed at modernizing the Unified Health System (SUS) and expanding the adoption of digital health. The Digital Health Strategy for Brazil 2020-2028 (ESD28) established guidelines for the integration of systems, capacity building, and digital transformation of the sector (Brazilian Ministry of Health [MS], 2020). The program Meu SUS Digital (My Digital SUS), implemented by MS, has allowed citizens to access health information, such as immunization records and test results, in a practical and integrated way. In addition, the National Health Data Network (RNDS) has promoted the interoperability between systems at different levels of health care, enabling the secure exchange of information between public and private healthcare facilities (MS, 2024). In this context, strengthening telehealth and training professionals are essential aspects of expanding access to health system and making it more efficient, accessible, and equitable.

In its 11th edition, the ICT in Health 2024 survey presents indicators that measure the adoption and appropriation of digital technologies in healthcare facilities and by physicians and nurses. The results indicate a continuum increase in the use of digital devices, Internet access, adoption of electronic systems, and telehealth in recent years. However, the incorporation of more complex technologies, such as Big Data analysis and Artificial Intelligence (AI) applications, is still limited within healthcare facilities. The scenario reveals that the most substantial uses are mainly in private facilities and inpatient facilities with more than 50 beds.

In this edition, the survey brings new indicators to help understand the provision of digital devices to healthcare professionals, deepen the investigation into the training of managers, physicians, and nurses in courses in the area of health informatics and about the topics covered, and assess the use of AI tools by professionals in the area.[1]

The "Analysis of Results" was structured into the following sections:

- Availability of ICT infrastructure in healthcare facilities and access for professionals in the sector;
- Management and governance of information technology (IT) and information security;
- Electronic health systems and the use of functionalities by health professionals;
- Online services offered to patients;
- Telehealth and its adoption by professionals in the field;
- Adoption of emerging technologies in healthcare facilities;
- Capacity-building and training of managers and professionals in health informatics;
- Final considerations: Agenda for public policies.

Availability of ICT infrastructure in healthcare facilities and access for professionals in the sector

Ensuring an ICT infrastructure that meets properly the demands of healthcare facilities is a key factor in integrating and improving their service provision through digital tools. Connectivity is not limited to broadband Internet or the use of up-to-date devices, but also covers expanding networks in remote areas, promoting equity in access, reducing digital inequalities, and facilitating access to digital health resources, such as telehealth. It also enables the production of robust data that can be used to develop technologies such as AI. Therefore, investment in ICT infrastructure, as well as being a technical necessity, must be linked to a strategy to reduce inequalities and promote quality health in all regions.

Access to ICT infrastructure has expanded significantly in recent years. In 2024, the results of the ICT in Health survey indicated the universal use of the Internet in Brazilian healthcare facilities, with an increase in access both in public facilities compared to that observed in 2023 (from 96% to 99% in 2024), and in facilities located in the North (from 90% to 99%) and Northeast (from 97% to 99%). There was also an increase in connectivity in inpatient facilities with more than 50 beds (from 97% to 100%) and in Primary Healthcare Units (PHU) (from 96% to 99%).

[1] It is worth noting that the data referring to healthcare professionals is compared to the 2022 edition because information about this public is collected biannually.

Cable or fiber optic connections were the most common in healthcare facilities (97% in 2024). The second most used connections were mobile connections via 3G or 4G modems or chips, which were more present in private facilities (61%) than in public ones (29%). DSL, the third most widely used type of connection, experienced a downward trend in the historical series (from 52% in 2015 to 33% in 2024), a pattern also seen with radio connection (from 20% in 2015 to 6% in 2024).

Another aspect of connectivity in Brazilian healthcare facilities is the maximum download speed contracted by the facilities. The results indicated that the most common speed was above 100 Mbps (38%), which was higher than in 2023 (33%). There was also a difference between private and public facilities in terms of connection speed: in the former, 49% had a speed above 100 Mbps, compared to 25% in the latter. However, it should be noted that around four out of ten managers of public facilities were unable to say what the contracted connection speed was. This result may reflect the fact that contracting Internet infrastructure services for some of these facilities is the responsibility of the health secretariats.

The survey also showed that the use of computers (desktops, laptops, or tablets) in facilities was practically universal, as 99% were using some type of computer. Noteworthy are the increases in PHU (from 96% in 2023 to 99% in 2024), in inpatient facilities with more than 50 beds (from 97% to 100%), in public facilities (from 96% to 99%), and in the North (from 93% to 99%) and Northeast (from 96% to 98%).

The results of the survey with healthcare professionals reinforced the expansion of computer access, with 99% of physicians and 99% of nurses reporting such availability in the healthcare facility where they worked. This proportion increased compared to 2022, the last time information was collected from healthcare professionals, when 89% of physicians and 96% of nurses said they had some type of computer available in their facility. In addition, the results of the survey revealed that 99% of physicians and nurses had Internet available in healthcare facilities, a proportion that grew significantly compared to that observed in 2022 (93% of physicians and 94% of nurses).

Regarding the types of computers used, the main devices were desktop computers (97%), with less use of laptops (68%) and tablets (39%). The use of laptops was higher in the private sector (81%) compared to the public sector (54%), as well as in inpatient facilities with more than 50 beds (89%), compared to PHU (53%), outpatient facilities (67%), inpatient facilities with up to 50 beds (73%), and those with diagnosis and therapy services (SADT) (71%). Tablets were most used in PHU (63%) and in public facilities as a whole (50%), this may be due to the use of these devices by family health teams and community agents who visit families and can register their data in the online system, without the need for manual registration. Among physicians and nurses, the most frequently reported device available was also desktop computers (99% and 97%, respectively), followed by mobile phones (91% and 84%), laptops (36% and 29%), and tablets (18% and 13%).

In 2024, the ICT in Health survey also began investigating the provision of mobile devices to people working in healthcare facilities. The results showed that 75% of facilities provided their workers with laptops, tablets, or mobile phones. Private healthcare facilities (79%), those located in the Northeast (78%) and South (79%), inpatient facilities with more than 50 beds (79%), and PHU (76%) stood out in this type of provision.

This data was complemented by indicators collected with physicians and nurses about the origin of the device available for use in the healthcare facilities. The survey explored whether the devices available were from the healthcare facilities or from the professionals and brought to the facilities. The use of laptops owned by physicians accounted for 40%, while this figure was 21% for nurses. In turn, the proportion of physicians who used their tablets was 76%while that of nurses was 28%, revealing a strong difference between the two groups in this respect. It should also be noted that mobile phones were the most used devices by professionals in healthcare facilities (89% of physicians and 73% of nurses).

The survey also provided indicators on how often physicians and nurses used computers during their work, whether in patient care or other activities carried out in the facilities. The results indicated stability in the proportion of physicians who said they always used computers in patient care (84%) and other medical activities (80%). In public facilities, the proportion of physicians who said they always used computers for other medical activities was 71%, while in private facilities, it was 87%. Also noteworthy is the increase in the proportion of nurses who said they always used computers when caring for patients: In 2022, it was 67%; in 2024, the proportion reached 83%. The same happened with the proportion of these professionals who said they always used computers in other nursing activities, which rose from 83% to 91% over the same period.

The results of the 2024 edition indicated that access to electronic devices and the Internet has expanded in recent years, suggesting the universality of their use in Brazilian healthcare facilities. However, it is important to emphasize that, in addition to access to this equipment, it is necessary to ensure that the quality of the connections is appropriate to the needs of each healthcare facility and the type of health services they provide to the population.

Management and governance of information technology (IT) and information security

The adoption and integration of digital technologies in healthcare, as well as the interoperability of data, are fundamental to the advancement of digital health in clinical practice. However, the development of these technologies needs to be guided by robust data governance capable of mitigating the risks associated with their use, relating to data privacy and completeness. Digital health governance requires the active participation of all sectors—governments, international organizations, civil society, and the private sector—in addition to multidisciplinary capabilities in work teams (Lopes, 2025).

The ICT in Health survey investigates aspects related to ICT governance in Brazilian healthcare facilities. To this end, it addresses issues such as financing, management, and the profile of the people responsible. With regard to financing, in 2021, there was a significant increase in the percentage of healthcare facilities that allocated specific resources to IT—reaching 62%—mainly because of the need to adopt technologies during the COVID-19 pandemic. However, there has been a gradual decline since then: By 2024, 48% of facilities had allocated resources for IT, a percentage close to the pre-pandemic period (52% in 2019). The main variations compared to 2023 were in private facilities (60% in 2023 to 53% in 2024), outpatient facilities (53% to 47%), and inpatient facilities with up to 50 beds (52% to 37%). Inpatient facilities with more than 50 beds (61% in 2024) and SADT (55% in 2024) also showed a decrease, although they were the ones that allocated the highest percentage of resources for this purpose.

Among the facilities that allocated specific resources for IT, 22% allocated up to 1.5% of their annual budget; 16%, between 1.6% and 3%; 12%, between 3.1% and 6%; and 13%, more than 6%. Inpatient facilities with more than 50 beds invested the most resources in IT, with 32% of them allocating more than 3% of their budget for this purpose. In the case of PHU (19%), outpatient facilities (22%), inpatient facilities with up to 50 beds (29%), and SADT (29%), the main range of IT investment was up to 1.5% of the budget.

The survey also investigates the presence of IT departments or areas in healthcare facilities. This indicator showed a significant reduction between 2022 and 2023, from 30% to 23% of healthcare facilities, and remained stable in 2024, as 25% of facilities had specific areas set aside for IT.

In the case of facilities that did not have IT departments, 30% of those responsible for IT were service providers hired by the Health Department and 24% were hired by the facilities themselves (Chart 1). There was also a significant decrease in the proportion of healthcare facilities in which in-house staff were responsible for IT, from 10% in 2023 to 6% in 2024.

In PHU, IT services were mostly provided by the Health Department (72%), and 10% had IT departments at the time of the survey. On the other hand, a higher percentage of inpatient facilities had IT departments, with 40% of facilities with up to 50 beds and 85% of those with more than 50 beds having them. These differences in the percentages of those responsible for IT can be explained by both the size of the facilities and by their administrative jurisdiction, since in the case of public healthcare facilities, this service is often concentrated in the health secretariats.

CHART 1

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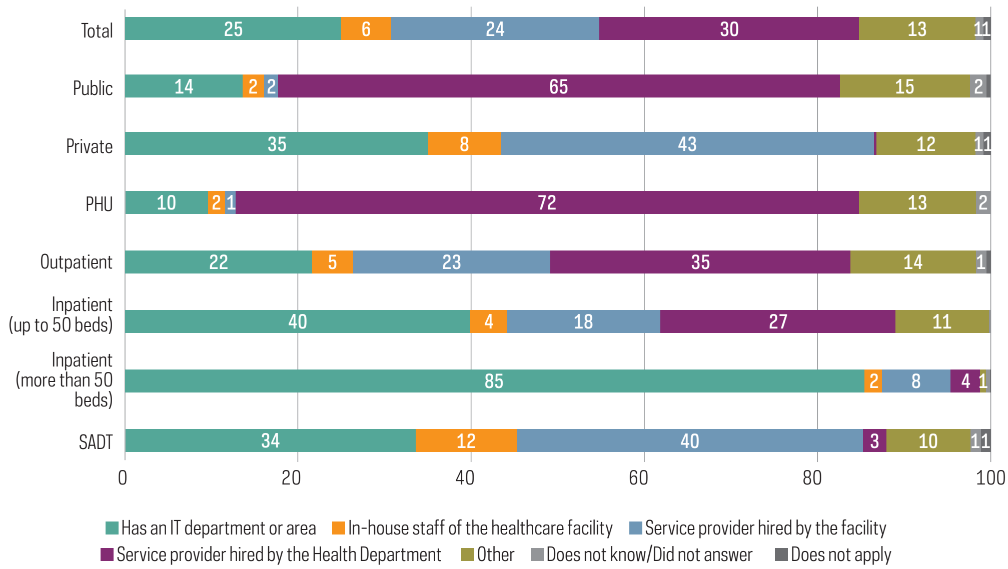
Healthcare facilities with an IT department or main responsible for IT (2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)



Another important aspect of ICT governance in healthcare facilities is the presence of multidisciplinary technology management teams. The proportion of facilities that had health professionals in their IT departments was 19% in 2024, with public healthcare facilities standing out, among which a quarter (25%) had health professionals on their IT staff, and SADT (21%). In 2024, 3% of these employees had a degree in medicine, 5% in nursing, and 14% in other health programs.

HEALTH DATA PROTECTION AND PRIVACY

The growing digitalization of healthcare facilities and the expansion of integrated health electronic records have increased the collection of patient information, a phenomenon that is linked to a series of potential benefits for the care and management of healthcare systems. However, much of this information is considered sensitive—such as illness histories and biometric data—and requires special care on the part of managers and employees when storing, processing, and handling it, in addition to greater adherence to information protection and security practices (Alegre et al., 2024).

Since 2014, the ICT in Health survey has produced indicators of how healthcare facilities have been working on data security issues. Since 2021, it has been measuring the adherence of these facilities to some of the measures set forth by the Brazilian General Data Protection Law — LGPD (Law No. 13.709/2018) and the guidelines set out by the National Data Protection Authority (ANPD, 2022, 2023a, 2023b; Campos & Santana, 2022).

According to this edition's data, less than half of healthcare facilities had documents outlining information security policies (42%). These documents were more common among inpatient facilities with more than 50 beds (73%) and SADT (61%). Documents of this type are also more present in private facilities (55%) compared to public ones (26%). This data provides a basis for further research into the motivations and capacities that lead to whether these types of documents are drawn up, to improve the health system's general adherence to data protection practices. It is also worth noting that the scenario was stable compared to 2023.

There were also disparities between public and private facilities and among the different types of facilities in relation to their provision and performance of information security training for their professionals, another topic investigated by the ICT in Health survey. Among healthcare facilities, only 47% reported having offered this type of training, 59% in the private sector and 34% in the public sector. In addition, outpatient facilities, inpatient facilities with more than 50 beds (68%), and SADT (64%) also carried out training in larger proportions (Chart 2).[2]

CHART 2

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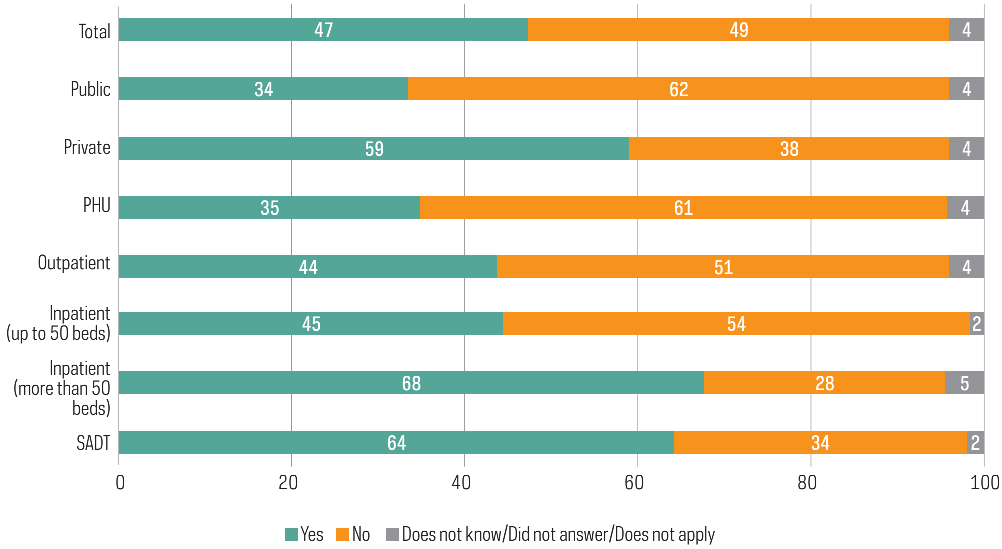
Healthcare facilities with an information security training program for employees (2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)



[2] It should be noted that, in 2024, this indicator was revised to include all facilities with computer access and therefore cannot be compared with previous years.

This topic was also surveyed directly with healthcare professionals. In 2024, 30% of physicians reported having taken a course or training in information security, and the percentage was higher among those working in private facilities (40%) than in public ones (17%). As for nurses, 33% had taken a course or training on the subject; following the same trend as physicians, the numbers were higher among nurses working in private facilities (49%) than among those working in public ones (24%).

There has also been progress in the use of information security tools in healthcare facilities. In 2024, there was a higher incidence of password-protected access to the electronic system, firewalls, cryptography of files and e-mails, digital certificates, and database cryptographyas showed in Chat 3. The other tools remained stable over the period.

CHART 3

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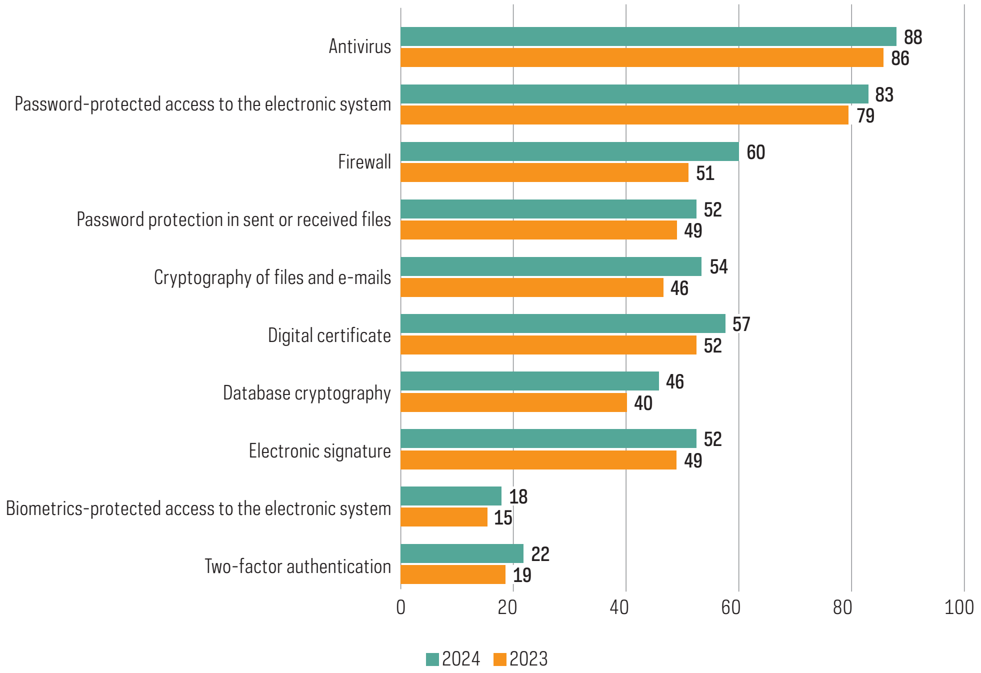
Healthcare facilities by type of information security tool used (2023–2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)



Regarding the measures adopted by healthcare facilities concerning the LGPD, it is worth noting that in 2024, around a third had appointed facility data protection officers (DPO) (30%), provided service and interaction channels with the data holders (31%), and implemented data security incident response plans (31%). The results indicate that there is room for improvement in this area, especially considering the importance of DPO in carrying out the multiple tasks defined in the legislation, as well as the greater adherence of other organizations to this guideline, such as among federal public organizations (Brazilian Internet Steering Committee [CGI.br], 2024b).

In addition, around a third (32%) of Brazilian healthcare facilities disclosed their privacy policies on the facility or health department websites, and 44% carried out internal awareness campaigns on the LGPD. It should be noted that 79% of healthcare facility managers agreed that the electronic systems used in the facilities were secure and guaranteed confidentiality and privacy, with stable results compared to 2023.

It is also worth emphasizing that there were significant differences for this indicator depending on the type of healthcare facility (Chart 4). Inpatient facilities with more than 50 beds and SADT were again the most advanced in applying security and privacy policy measures. For this indicator, PHU lagged behind other types of facilities, especially when appointing DPO (13%) and implementing information security incident response plans (12%).

CHART 4

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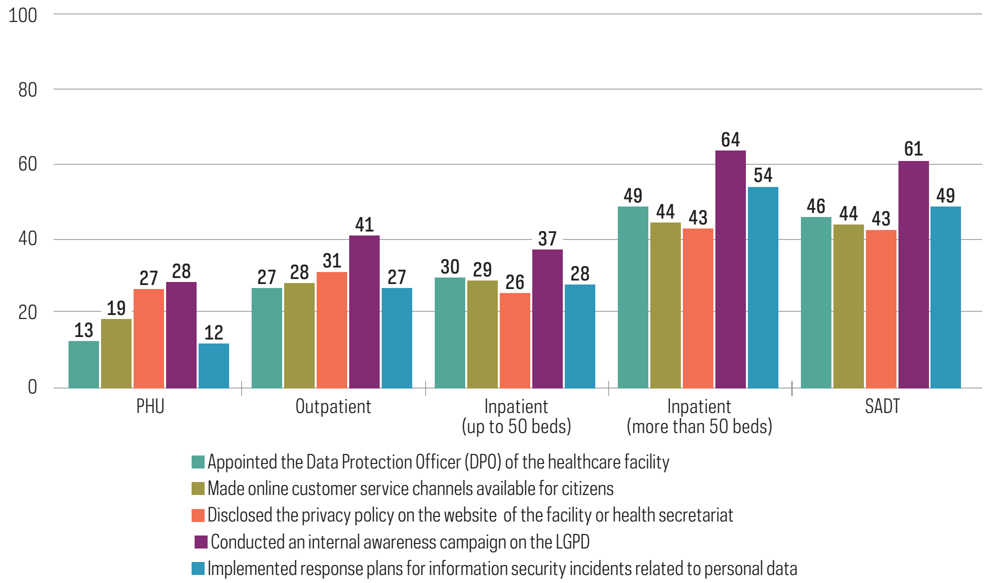
Healthcare facilities by measures adopted concerning the LGPD (2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)



Electronic health systems and the use of functionalities by health professionals

Adopting electronic systems for recording patient information contributed to the improvement of health information management, optimizing and providing greater patient safety during the care journey. Its implementation not only allows higher quality of clinical records but also favors the interoperability of data between different healthcare facilities, allowing for more coordinated and efficient care (Pan American Health

Organization [PAHO], 2020). This integration is essential in contexts where patients need to access services at multiple points in the care network, facilitating continuity of care and reducing redundancies in information and resources. The World Health Organization (WHO) also emphasizes the importance of interoperability as a pillar for the digital transformation of global health systems (WHO, 2022).

For the best use and appropriation by professionals, electronic systems need to be in line with the needs of their users, invest in usability, and contribute to improving workflows, relying on the best practices of digital health governance and management in healthcare facilities. Another point of attention is that much of the health data is still unstructured, making it difficult to use it for quality measurement, scientific research, and decision support (Ebbers et al., 2024). In these cases, adopting systems and algorithms that deal with unstructured information—which requires teams trained in its use—can provide support.

In recent years, the adoption of electronic systems to record patient information has been increasing in Brazil and, by 2024, had reached 92% of healthcare facilities (in 2023 they were present in 87%). Among the survey strata, this increase occurred mainly in public facilities (85% in 2023 to 90% in 2024), private facilities (90% to 93%), outpatient facilities (87% to 92%), and PHU (89% to 97%).

This increased use of electronic systems has had an impact on the way clinical and demographic information is stored. In general, this information was kept partly paper-based and partly in electronic format (55%). There was an increase in the number of healthcare facilities that only kept patient information in electronic format (37%), compared to the 2023 results (32%), and in inverse proportion, there was a decrease among those that only kept patient information on paper (from 11% in 2023 to 6% in 2024).

The results of the survey also indicated that PHU were more digitalized and that they collected, stored, and made available more patient data in electronic format. In 2024, 57% kept patient information partly paper-based and partly in electronic format, and 41% stored it only in electronic format. As for the digital availability of data, between 2023 and 2024, there was a significant increase in relation to patient demographics, detailed clinical notes from encounters with clinicians or medical history, prescribed medication lists, and patient admission, referral, and discharge, as shown in Chart 5.

CHART 5

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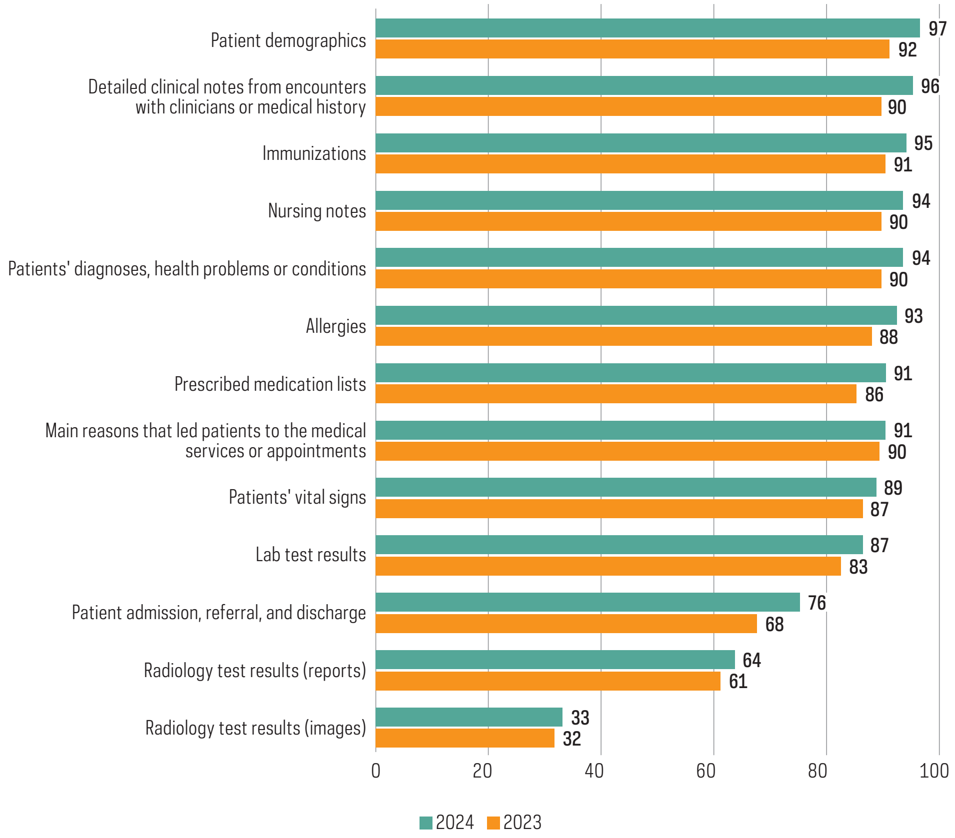
PHU by types of patient data available electronically (2023–2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)



A positive aspect of the digitalization of healthcare facilities is the increase in the percentage that makes patient data available in electronic format in recent years. Among the types of patient information investigated by the survey, the data most commonly available electronically was patient demographics, made available in 90% of facilities, followed by detailed clinical notes from encounters with clinicians or medical history (80%), lab test results (72%), and patient admission, referral, and discharge (61%). In turn, radiology test results (images) of patients were the only type of data present in less than half of the facilities (37%).

Another important topic is the use that healthcare professionals make of this electronically available data. To better understand this dimension, the survey investigates both its availability to professionals and the frequency of its use. The results indicated that more than half of physicians and nurses consult the data available electronically with high frequency (always). In the case of physicians, emphasis goes to the main reasons that led patients to the medical services or appointments, patients' diagnoses, health problems or conditions, and lab test results, which were always consulted by more than 70% of physicians (Chart 6). In the case of nurses, the main data accessed electronically were patients' diagnoses, health problems or conditions, the main reasons that led patients to the medical services or appointments, and nursing notes (Chart 7).

CHART 6

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Physicians by how often they refer to the available electronic patient data (2024)

Total number of physicians with computer access in the healthcare facilities (%)

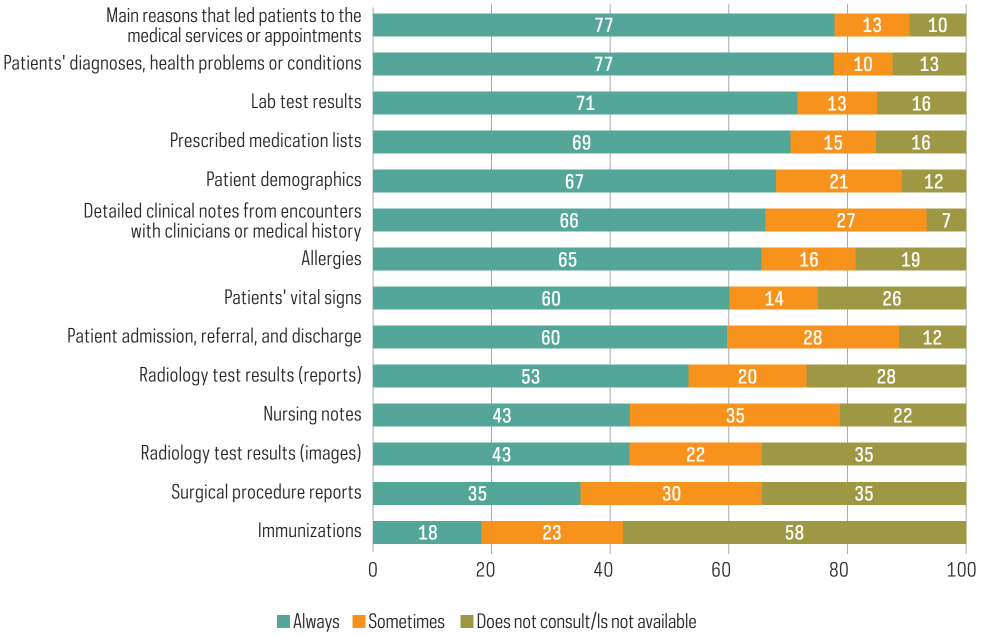

CHART 7

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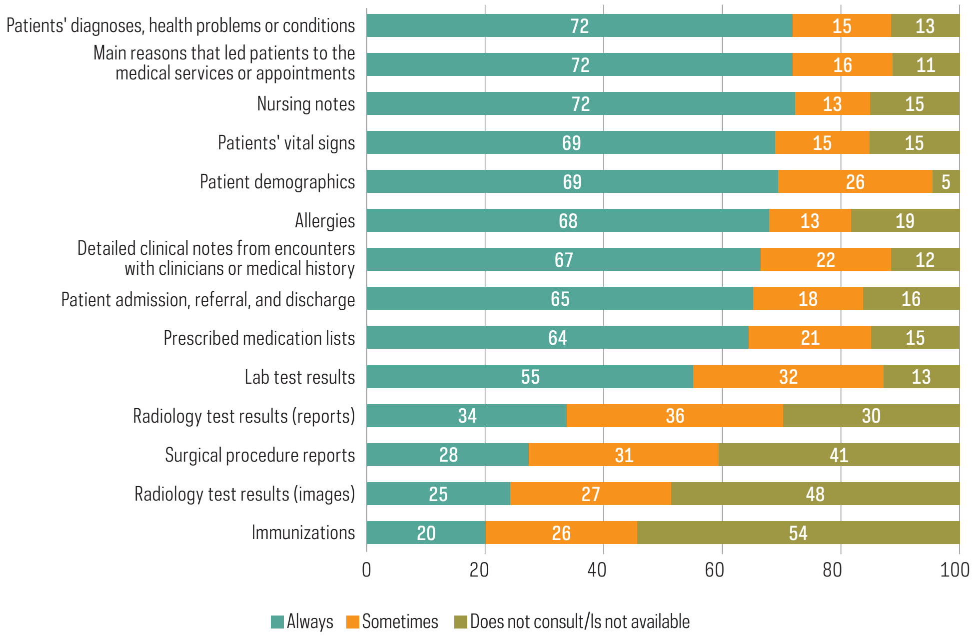
Nurses by how often they refer to the available electronic patient data (2024)

Total number of nurses with computer access in the healthcare facilities (%)



The functionalities available in the electronic systems used in healthcare facilities are another topic investigated by the survey, which helps to understand how digital technologies can contribute to the routine of managers and professionals, whether in administrative processes or in clinical care. In 2024, the functionalities that helped administrative flows were the most present in healthcare facilities, such as booking appointments, tests, or surgeries (65%), requesting lab tests (63%), and writing medical prescriptions (62%). In turn, functionalities aimed at supporting clinical decisions appeared in less than half of the healthcare facilities, such as clinical guidelines, best practices, or protocols (38%), drug allergy alerts and reminders (31%), alerts and reminders of allergies to food and surgical tape (29%), and contraindication alerts and reminders (28%), as can be seen in Table 1. These electronic system functionalities were present at a higher percentage of inpatient facilities.

TABLE 1

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Healthcare facilities by available electronic system functionalities (2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)

	Total	PHU	Outpatient	Inpatient (up to 50 beds)	Inpatient (more than 50 beds)	SADT
Booking appointments, tests, or surgeries	65	72	67	71	83	42
Requesting lab tests	63	85	66	61	83	34
Writing medical prescriptions	62	90	68	68	86	12
Generating requests for materials and supplies	57	65	57	63	83	51
Requesting imaging tests	56	77	62	54	79	16
Listing lab test results for a specific patient	53	65	50	52	74	65
Requesting medications	50	72	54	61	78	12
Clinical guidelines, best practices, or protocols	38	38	37	44	61	40
Drug allergy alerts and reminders	31	33	31	37	61	20
Alerts and reminders of allergies to food and surgical tape	29	33	29	35	54	21
Contraindication alerts and reminders	28	27	28	35	50	24

The survey also investigated the use and frequency of use of the functionalities of electronic systems, as shown in Charts 8 and 9. With regard to physicians, around half reported always listing medications being taken by a specific patient (51%), followed by always listing lab test results for a specific patient (46%), and always requesting lab tests (45%). As for nurses, the main functionalities that were always used were generating requests for materials and supplies (43%), listing medications being taken by a specific patient (31%), and listing lab test results for a specific patient (27%), although these functionalities were used more frequently by less than half of the nurses.

CHART 8

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Physicians by how often they use the available electronic system functionalities (2024)

Total number of physicians with computer access in the healthcare facilities (%)

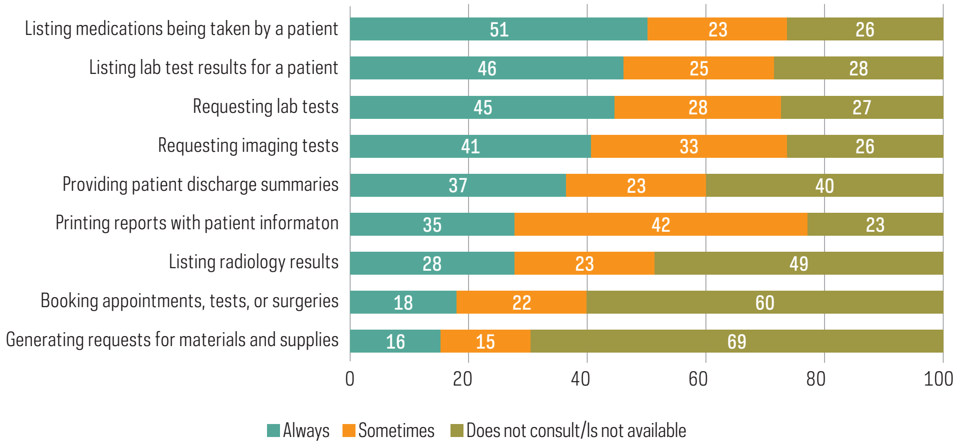

CHART 9

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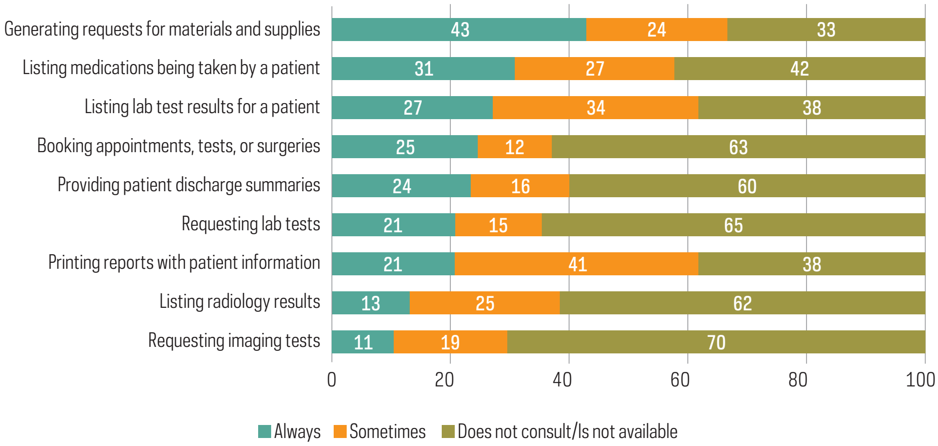
Nurses by how often they use the available electronic system functionalities (2024)

Total number of nurses with computer access in the healthcare facilities (%)



Finally, among the uses of electronic tools to assist in clinical activity, the survey also investigated the use of electronic prescriptions by healthcare professionals. This is a tool that contributes to the transformation of the medicine management landscape and is a central support for telemedicine. This technology has replaced traditional paper prescription methods and allows electronic transmission, which can contribute to significant improvements in the management, accuracy, and safety of drug prescriptions worldwide (Hareem et al., 2024). However, in Brazil, medicine prescription is mainly carried out in a mixed format, with a low percentage being written entirely electronically.

In 2024, the main means of writing prescriptions was by computer, in electronic and printed format, for both physicians (64%) and nurses (52%). Only 12% of physicians and 15% of nurses wrote prescriptions by hand. However, although most wrote prescriptions on computers, 70% of the physicians signed the forms by hand and only 15% signed them using digital certificates. Among nurses, 60% signed the printed prescriptions by hand and 21% used digital certificates.

The results of the ICT in Health 2024 survey related to the use of electronic systems and tools to assist in the flow of administrative and clinical processes indicated that they are more widely available in healthcare facilities.

Health data plays a strategic role in drawing up public policies, monitoring population health, and promoting scientific research. The quality and diversity of this data are crucial for generating knowledge that represents the reality of different segments of the population. The greater the diversity of data collection, the greater the ability to identify patterns and inequalities, promoting evidence-based decisions (Raghupathi & Raghupathi, 2014). In this context, efforts to computerize health systems and include facilities of different sizes and profiles are essential to increasing equity and efficiency in care.

Online services offered to patients

Providing patients with online services, such as booking appointments and lab tests, as well as access to their own data (such as test results) and viewing medical records, strengthens their autonomy and engagement in health care and well-being. In addition, consultation tools and interactions with medical teams can extend the reach and convenience of healthcare services and play an important role in modernizing and expanding access to healthcare (Sharma et al., 2018). WHO emphasizes that these innovations are key to overcoming geographical barriers and improving healthcare, especially in areas where real-time care is less available (WHO, 2016).

Access to health information is among the most searched topics online, according to data from the ICT Households survey (CGI.br, 2024a). In 2024, around half of Internet users (51%) searched for this type of information. Among digital public services, those related to health are the most sought after by Internet users: Almost a third (32%) reported looking for public health information or services in 2024.

The ICT in Health survey investigates the online presence of facilities, covering both the presence of websites and social network profiles and the availability of online services for patients. As for the availability of websites, in 2024, half of the healthcare facilities had their own pages (50%), and this proportion was higher among SADT (78%) and inpatient facilities with more than 50 beds (75%).

A higher proportion of private facilities had websites (77%) compared to public ones (19%). The explanation for this difference may lie in the centralization of health information and services on the pages of health secretariats and bodies responsible for public facilities.

As for the presence on the Internet through their own profiles or accounts on social networks, the results indicate an increase from 53% in 2023 to 57% in 2024, also with a larger share of private healthcare facilities (84%) compared to public ones (25%). Differences were also seen in SADT (86%), compared to inpatient facilities with more than 50 beds (73%), inpatient facilities with up to 50 beds (58%), and outpatient facilities (52%).

As for the services offered to patients via the Internet by Brazilian healthcare facilities, the types investigated by the survey range from viewing lab test results, offered by 34% of healthcare facilities in 2024, to booking appointments (31%) and tests (29%) and viewing electronic medical records (16%). Viewing test results stands out because it was the service most offered by SADT (74%) and inpatient facilities with more than 50 beds (48%), as shown in Chart 10.

CHART 10

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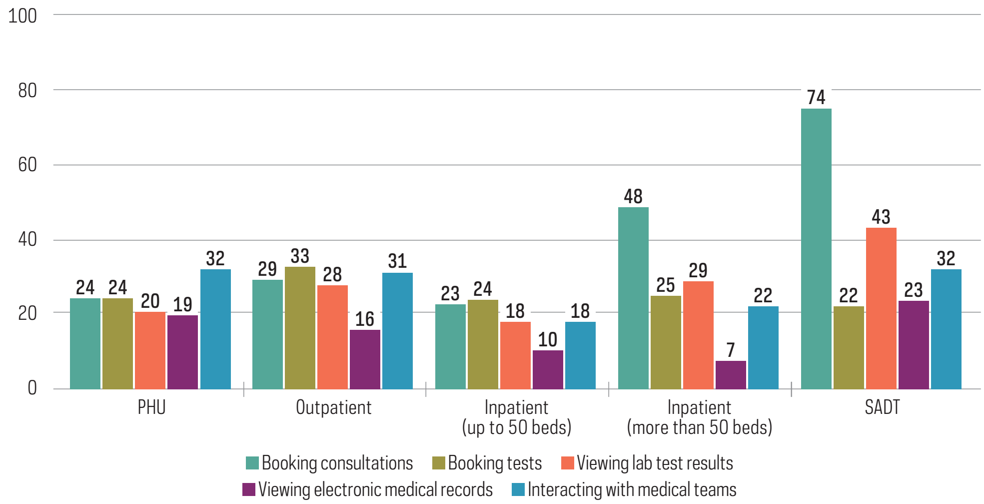
Healthcare facilities by services offered to patients through the Internet (2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)



In this edition of the survey, the main change was in the presence of services that allow patient interaction with medical teams through the Internet, which saw a significant increase compared to 2023, from 16% to 30% in 2024. This increase occurred mainly in PHU (from 17% to 32%), in outpatient facilities (from 17% to 31%), and in SADT (from 13% to 32%). It is worth noting that interaction with medical teams through the Internet can facilitate communication between patients and healthcare professionals in situations that require timely guidance or continuous monitoring, such as in cases of chronic illnesses.

Telehealth and its adoption by professionals in the field

Telehealth services are important tools for expanding the access to health care in Brazil, as they facilitate the population's access, especially in remote regions, to care, education, and monitoring services. They also help to reduce the number of users in health units, as well as reducing costs and waiting times before receiving care (Cezário, 2024). For progress to be made in the adoption of these tools, guidelines and standards are needed to guide the actions of professionals and the collection, storage, and protection of data from these services.

In this context, the Brazilian Ministry of Health recently instituted the Strategic Action SUS Digital-Telehealth (Estratégica SUS Digital – Telessaúde), aimed at supporting the consolidation of healthcare networks (Ordinance GM/MS No. 3.691/2024). This program establishes guidelines for services such as teleconsulting, teletriage, teleconsultation, telediagnosis, telemonitoring, tele-interconsultation, tele-education, teleregulation, and teleguidance. Actions must be carried out by duly registered professionals using digital platforms, guaranteeing ethics and confidentiality, and obtaining patients' informed consent. Care must also be recorded in clinical records according to established standards.

To monitor the progress of the use of telehealth in the country, the ICT in Health survey investigates the adoption of these services by facilities and their use by physicians and nurses. Regarding healthcare facilities, it was found that, in 2024, teleconsulting services were present in almost a third (30%), with a higher percentage in public facilities (38%) than in private ones (23%). Teleconsultation services were offered by almost a quarter of Brazilian healthcare facilities (23%), with no distinction between public and private. Telediagnosis services (23%) were provided by a higher proportion of private healthcare facilities than public ones (Chart 11).

CHART 11

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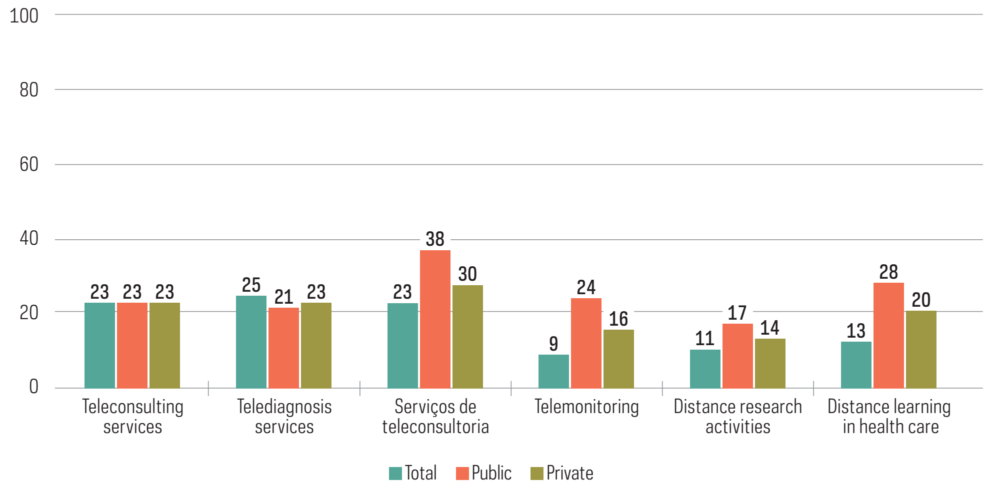
Healthcare facilities by telehealth services available (2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)



On the other hand, distance learning services in health care were offered by 20% of healthcare facilities, 28% of which were public and 13% were private. Also, services such as telemonitoring were offered by 16% of healthcare facilities. It should be emphasized that there was an increase in the provision of telemonitoring in public facilities, from 19% in 2023 to 24% in 2024. It is worth noting that inpatient facilities with more than 50 beds (33%) and SADT (29%) provided the most telediagnosis services. Teleconsultation services, on the other hand, were more commonly offered in PHU (25%) and outpatient facilities (26%).

As for access to telehealth services by healthcare professionals, the results showed that distance learning played an important role in the training and qualification of nurses and physicians. In the case of nurses, this was the service that was most available (59%) and was also the most used, with 10% always using it and 45%, sometimes. For physicians, this service was available to 49%, 12% of whom always used it and 34%, sometimes. The adoption of digital technologies in educational processes has qualified health professionals to handle digital tools and provide quality and safe distance care (Araújo et al., 2023).

Other telehealth services, such as distance research activities and telediagnosis, were available to 37% and 33% of nurses, respectively. With regard to physicians, telediagnosis (52%) was the telehealth service they had the most access to: 23% said they always used it and 20% sometimes used it. The telehealth services that were least available to physicians were teleconsulting and telemonitoring. Finally, teleconsultation was the tool least available to both nurses (19%) and physicians (26%), and it was also used less frequently by them (Charts 12 and 13).

CHART 12

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Physicians by how often they used telehealth services (2024)

Total number of physicians with computer access in the healthcare facilities (%)

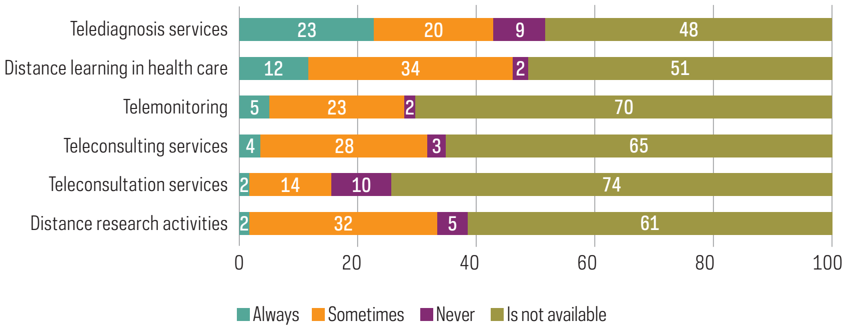

CHART 13

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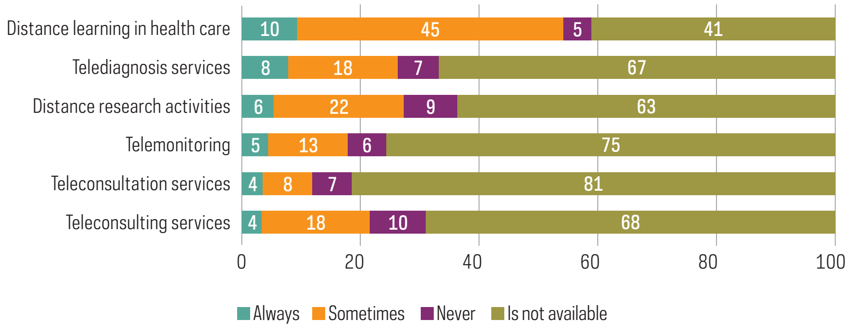
Nurses by how often they used telehealth services (2024)

Total number of nurses with computer access in the healthcare facilities (%)



These results indicated some progress in the provision of online services to patients, but in most strata, both online and telehealth services were provided by a low percentage of healthcare facilities. Therefore, significant challenges remain for expanding the supply of these services in the country, as well as for making greater use of them in teaching and research.

Adoption of emerging technologies in healthcare facilities

The use of emerging technologies, such as cloud services, AI, the Internet of Things (IoT), and robotics, has contributed to healthcare by providing advances in the quality, efficiency, and accessibility of services. AI has the potential to generate accurate and personalized diagnoses, optimizing the clinical decision process and supporting healthcare professionals in the early identification of diseases. IoT connects medical devices, allowing remote monitoring of patients and continuous management of chronic conditions and reducing hospitalizations and costs. Robotics has transformed surgical procedures, offering greater precision and reducing patient recovery times.

When integrated into healthcare systems, these technologies can improve clinical care, help with process flow and information security, and provide equitable access to healthcare, especially in remote regions with few resources. In this context, data from the ICT in Health survey helps map out the scenario of the application of these emerging technologies in Brazil.

Cloud services stand out as the most widely used emerging technology, present in both administrative jurisdictions and in different types of facilities. These services can help other emerging technologies to develop and be adopted by healthcare facilities. The results indicated that e-mail (63%) and file storage or database (52%) were the main cloud services used by healthcare facilities. To a lesser extent, 35% used cloud processing capacity, and 29% used cloud office software. Cloud services were used to a greater extent by private healthcare facilities and SADT (Chart 14).

CHART 14

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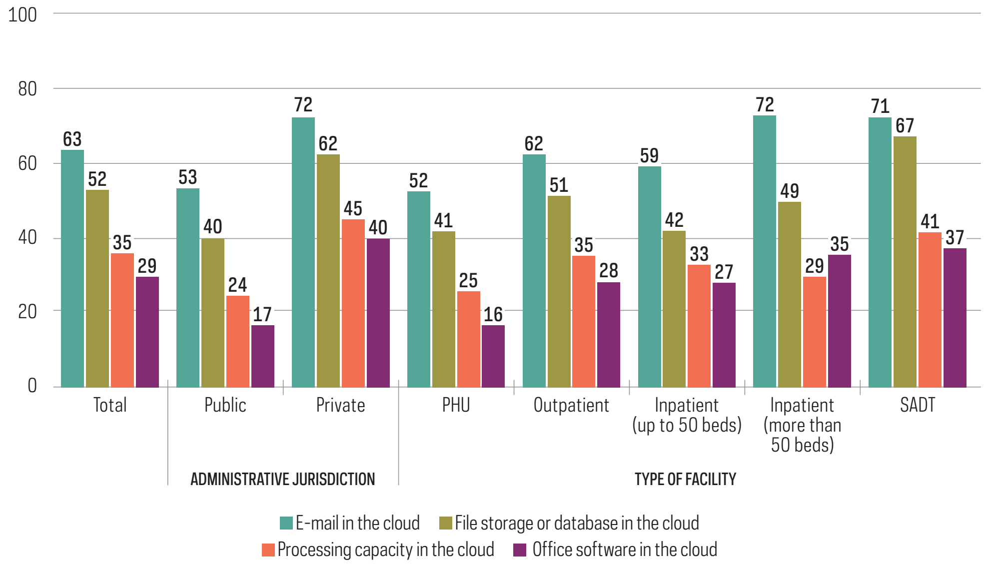
Healthcare facilities that used cloud services (2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)



Big Data analytics, on the other hand, were reported on a smaller scale. This type of use was mentioned by only 5% of the healthcare facilities that used the Internet. In PHU, this figure was even lower (2%), while in most other facilities the figure was close to the average, at no more than 6%. The only exception was for inpatient facilities with more than 50 beds; 23% reported having performed Big Data analytics—around four times more than for the other types.

This disparity between the different types of facilities is due to multiple factors, which go beyond access to budgetary resources. The use of Big Data analytics depends on systematic mechanisms for producing, storing, and constantly processing information (Salganik, 2017), which requires not only adequate technological infrastructure, but also people trained in its operation. At the same time, the effectiveness of the analyses depends on the volume and quality of the data available, so larger facilities, in addition to having greater access to the resources (financial and operational) required for their use, tend to find greater effectiveness and functionality in their use.

Most Big Data analytics were carried out using the healthcare facilities' own data, from smart devices or sensors (72%) and that originating in patient demographics, forms, and medical records (65%). In addition, data generated from social media, such as social networks, multimedia content sharing sites (48%), and geolocation data from the use of portable devices such as mobile phones, wireless connections, or GPS (38%) stand out. Compared to 2023, there was greater use of data from smart devices or sensors for Big Data analytics (from 63% in 2023 to 72% in 2024) and less use of data from patient demographics, forms, and medical records (from 73% to 65%). It is also worth noting that most Big Data analytics were carried out by in-house staff (77%), while external providers were responsible for them in 23% of facilities.

The results of the ICT in Health 2024 survey indicated that, among healthcare facilities with Internet access, only 1% used blockchain technologies, 2% robotics, and 4% IoT. This use, which is generally quite restricted, becomes more significant—as with Big Data analytics—when we look at data from inpatient facilities with more than 50 beds. Among these, 5% reported having used blockchain technologies, 14% robotics, and 19% IoT.

TABLE 2

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Healthcare facilities by types of technology used (2024)

Total number of healthcare facilities that used the Internet in the last 12 months (%)

Facilities	Blockchain		Robotics		IoT	
	%	Abs. Val.	%	Abs. Val.	%	Abs. Val.
Total	1	1 442	2	3 219	4	4 797
Public	0	148	1	396	1	597
Private	2	1 294	4	2 823	6	4 200
Outpatient	1	1 078	1	1 193	3	2 921
Inpatient (up to 50 beds)	2	83	4	211	5	255
Inpatient (more than 50 beds)	5	143	14	421	19	574
SADT	1	139	9	1 394	7	1 046

This significant disparity between the appropriation of emerging technologies in the different types of healthcare facilities may be the result of their different capacities and needs for use. It is worth noting in this regard that in the case of blockchain, robotics, and IoT, there was also a large gap between the public sector (with results between 0% and 1% for the three tools) and the private sector (with values between 2% and 6%).

AI IN HEALTH CARE

The potential and risks of AI tools have been gaining more and more ground in discussions about digital health in Brazil. The results of the ICT in Health 2024 survey indicated that these tools were still used by a limited number of healthcare facilities in the country—in general terms, AI was present in 4%. This resource was more present in inpatient facilities with more than 50 beds (16%) and in SADT (7%). In addition, there was a difference in adoption between public facilities (1%) and private ones (6%).

In this edition, the survey has introduced more detailed indicators regarding the use of AI by professionals in the field, allowing for a greater understanding of this scenario. A new indicator of the appropriation of generative AI tools was developed, which also provides data on the type of use made of them by healthcare professionals.

Generative AI is an advanced technology that creates content automatically in response to commands written in natural language. Unlike traditional systems, which only retrieve existing information, generative AI can generate new content, such as texts, images, videos, music, and even software code. Models such as OpenAI's ChatGPT and Google's Gemini are examples of this type of technology, which is based on large language models (LLMs). In health care, these tools can be used to analyze unstructured clinical texts such as medical records, clinical notes, and discharge summaries. Their applications include acting as chatbots to communicate with patients, translating documents, generating clinical reports, and even offering support in detecting diseases by analyzing medical images. In addition, generative AI can be applied in pharmacovigilance, identifying adverse drug reactions reported in texts and helping to ensure patient safety (Hospital Italiano de Buenos Aires [HIBA], 2024).

Despite the potential benefits, the integration of generative AI into health care requires caution. One of the main challenges is the need for transparency in the results generated so that medical professionals can trust its recommendations. To this end, it is essential to develop Explainable Artificial Intelligence (XAI) that makes processes more understandable and reduces the risk of errors and biases. In addition, it is necessary to consider ethical issues, prioritize the privacy and security of confidential patient data, establish adequate consent mechanisms to ensure that patients are aware that their data is being used by algorithmic models, and mitigate biases in the models (HIBA, 2024). These aspects, combined with their importance in the debate on AI in health care, point to the importance of monitoring its progress in healthcare practice in the country.

The results indicated a close frequency of use of generative AI resources in healthcare facilities between physicians (17%) and nurses (16%) with computers. These figures varied according to administrative jurisdiction (professionals in the private sector used it more than in the public sector) and type of facility (Chart 15). There was, however, another variable that stood out in the analysis of the specific indicator of the use of generative AI by healthcare professionals: age. While 9% of physicians up to 35 years old and 9% of those 51 years old or older used these resources, this percentage was 29% for those 36 to 50 years old. For nurses, use was 7% among those up to 30 years old, 16% among those 31 to 40 years old, and 21% among those 41 years old or older.

CHART 15

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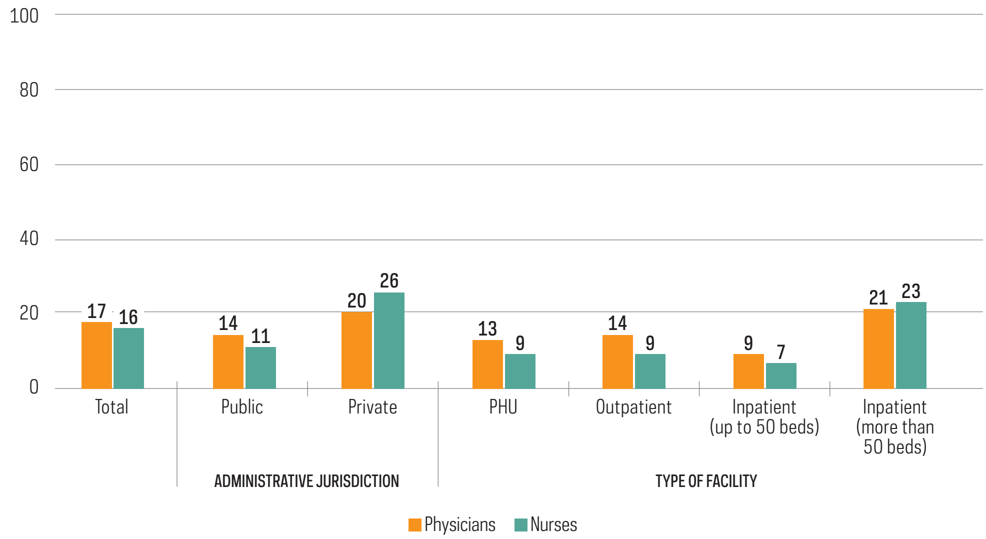
Physicians and nurses by use of generative AI (2024)

Total number of physicians and nurses with computer access in the healthcare facilities (%)



Age is also relevant to understanding another new indicator in the survey, which refers to the types of application of generative AI resources by physicians and nurses (Chart 16). For physicians, the most common use was assisting with research (reported by 69% of physicians who used generative AI), followed by assisting with reports inserted into medical records (54%) and assisting with communication within work teams (45%). Among younger professionals, use for research was more disparate than the other options (59%, compared to 16% for reports and only 4% for communication). Among physicians using generative AI, three out of four reported having used other features of this technology.

Among nurses, the use of these resources to conduct research was even more pronounced: 86% of those who used generative AI performed this type of use, and it was prominent in all age groups. The use to assist with reports inserted into medical records was lower among nurses (34%) than among physicians and was significantly affected by age (59% among those up to 30 years old, 27% among those 31 to 40 years old, and 35% among those 41 years old or older). Use for communication within work teams was higher among nurses (66%) than among physicians (45%). The percentage of nurses who reported having used other generative AI resources was 75%.

CHART 16

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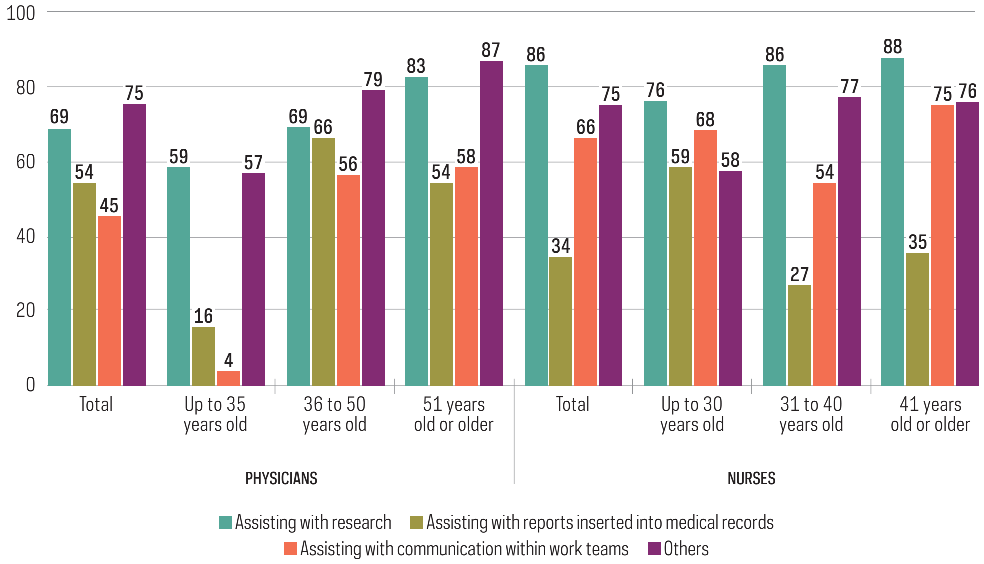
Physicians and nurses by types of applications of generative AI resources (2024)

Total number of physicians and nurses with computer access in the healthcare facilities (%)

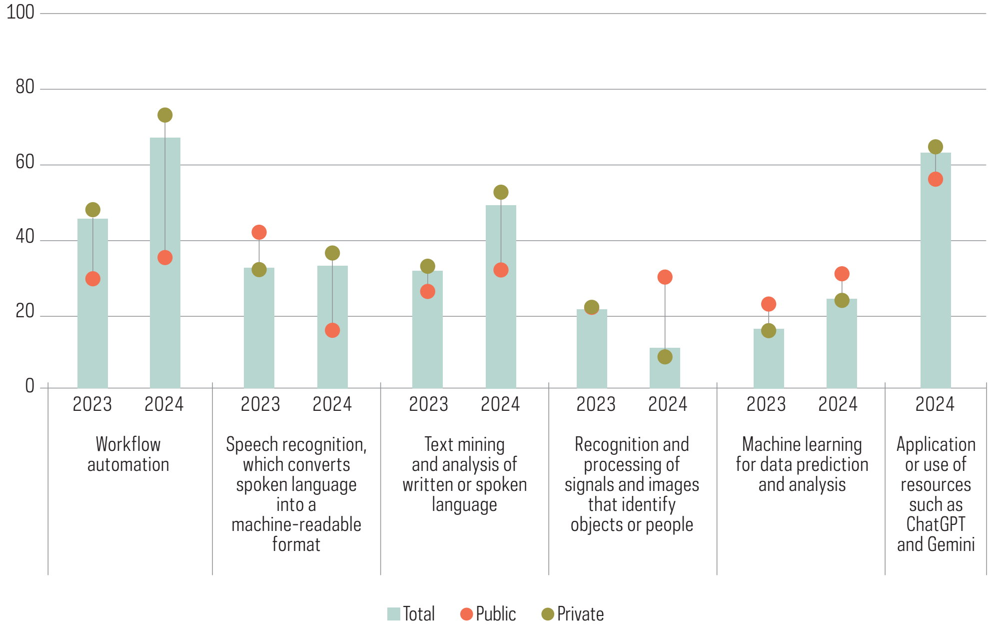


ICT in Health 2024 also provides indicators of the types of AI resources used in healthcare facilities and how they were applied. Of particular note in the first category was the use for workflow automation processes (carried out by 67% of healthcare facilities that used AI technologies), the application or use of resources such as ChatGPT and Gemini (63%), and text mining and analysis of written or spoken language (49%), as shown in Chart 17. In public facilities, the recognition and processing and images that identify objects or people were used by 29% (8% in the private sector), machine learning was used for data prediction and analysis by 30% (23% in the private sector) and speech recognition, in turn, was used more in the private sector (36% against 16%), as seen in Chart 17.

CHART 17

Healthcare facilities by types of AI resources used (2024)

Total number of healthcare facilities that used AI technologies (%)



The use of AI applications in healthcare facilities was mainly aimed at improving digital security (50%). However, other purposes were also mentioned, such as assisting in the organization of clinical and administrative processes (32%), improving treatment efficiency (29%), supporting logistics processes (27%), assisting with diagnoses (22%), supporting human resource management or recruitment (18%), and assisting in the dosage of medications according to the patients being treated (14%).

Finally, the ICT in Health survey showed data on the reasons for not using AI in healthcare facilities. There were significant differences between public and private sector facilities (Chart 18). Lack of need or interest (67%) and not being a priority (66%) topped the reasons reported by private facilities, followed by concerns regarding privacy and data protection violations (51%), and the fact that costs seem to be very high (48%). In the public sector, high cost was the second main justification (53%), behind incompatibility with existing equipment, software, or systems in the healthcare facilities (60%). Lack of trained people (51% in the public sector and 39% in the private sector) and difficulties regarding the availability or quality of the data required for using these technologies (49% in the public sector and 40% in the private sector) were also reasons frequently given by public facilities.

Ethical reasons were the least mentioned reason for not using AI (27%), reported by only three out of ten facilities in the private sector and two out of ten in the public sector. It is worth noting that in 2024, compared to 2023, the number of mentions of privacy and data protection concerns rose (47% compared to 39% in 2023) and the proportion of managers who mentioned lack of need or interest increased significantly (49% to 59% in 2024), while the percentage of mentions related to infrastructure or software incompatibility decreased (46% and 52%).

CHART 18

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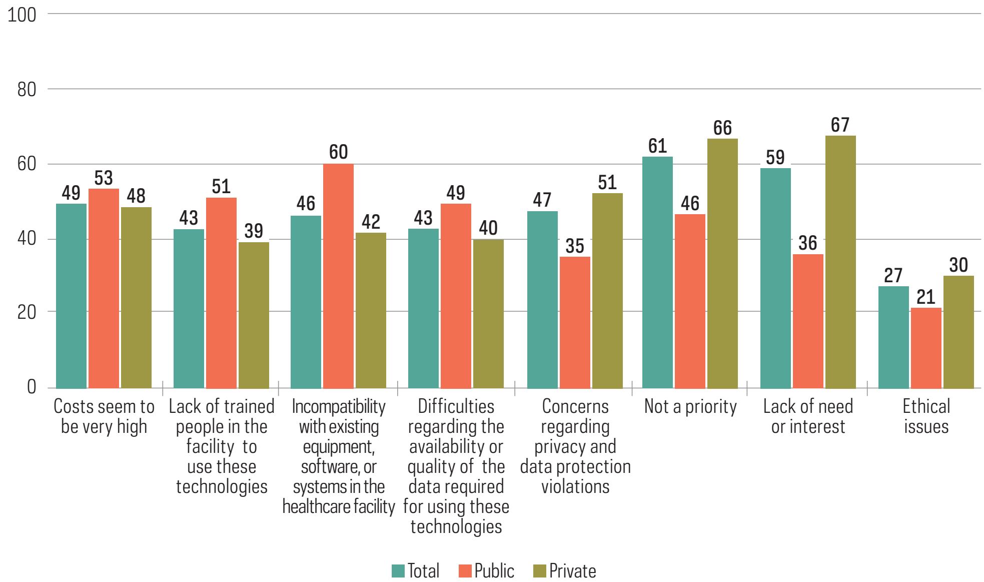
Healthcare facilities by reasons for not using AI technologies (2024)

Total number of healthcare facilities that did not use AI technologies (%)



BOX

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AI IN HEALTH: PERSPECTIVES AND CHALLENGES

Against the backdrop of advances in the development of AI tools and the expansion of their use in various sectors, the Regional Center for Studies on the Development of the Information Society (Cetic.br) has been conducting research that seeks to deepen knowledge and dialogue on the use of these technologies in the country. In 2024, the Sectoral Study *Artificial Intelligence in healthcare: Potential, risks, and perspectives for Brazil* (Brazilian Network Information Center [NIC.br], 2024) was carried out, which sought to investigate the current state of the application of AI in the health area and the challenges and opportunities arising from this scenario. Based on interviews with key players in the sector, this report gathered information for the debate on the appropriation of emerging technologies in the country's healthcare facilities, a topic that has been investigated by the ICT in Health survey since 2021.

Regarding the application of AI in health, an optimistic outlook prevailed among the interviewed stakeholders, for whom the opportunities outweighed the challenges and risks. The use of integrated data to monitor and act in epidemic scenarios, support for decision-making by healthcare professionals, and optimization of facility management were some of the high-impact functionalities attributed to the use of AI. From this perspective, there are benefits for populations/users (especially in terms of increased access and quality), system management (increased productivity, better management of resources, and reduced costs), healthcare professionals (support for care and reductions in the burden of bureaucratic activities), and health surveillance (monitoring of diseases and support for public prevention policies).

In addition, according to the actors interviewed, the use of machine-learning (ML) and deep-learning (DL) mechanisms in health care can help tackle substantial challenges in the Brazilian healthcare system, such as rising costs, a shortage of professionals, and difficulties linked to ongoing demographic changes. There is also an understanding that the Brazilian scenario has favorable factors for this type of application, given that the presence of an integrated data system, as well as established data protection laws and regulations, coupled with the country's population diversity, can favor the training of robust algorithms geared towards different field applications, without putting users' privacy and security at risk.

On the other hand, the study points to the understanding that, in Brazil, taking advantage of all these opportunities is still limited by the prematurity of the application of AI in health, as indicated above. Difficulties linked to the integration of databases, the training of professionals, and lack of resources are still obstacles to the development of the field, especially affecting the public sector.

The indicators from the ICT in Health survey relating to AI adoption and appropriation, together with the sectoral study of AI in health, contribute to a more in-depth understanding of the issue among professionals in the field. Given the multiple opportunities associated with using this type of resource in the field, this survey provides information on its applications and the motivations behind its use. The survey's goal is to contribute to the development of studies and policies aimed at improving the accessibility and quality of health care, management, and work in Brazil.

Capacity-building and training of managers and professionals in health informatics

The transition to increasingly digital health systems requires managers and professionals in the field to develop skills that integrate technical knowledge, practical skills, and attitudes in line with contemporary demands. Competency-based education and training stand out as key approaches in preparing these professionals to use digital technologies effectively, safely, and in a people-centered way. Empowering managers and teams to navigate complex systems, promoting digital inclusion, and integrating technological advances into clinical practice and management make it possible to strengthen healthcare systems, improve the quality of services, and expand equitable access to health (WHO, 2022).

Knowledge of health informatics has become increasingly important in the training of professionals in the field and is even one of the priorities of the Digital Health Strategy for Brazil 2020-2028 — ESD28 (MS, 2020). Priority 5, which focuses on the education and training of human resources for digital health, indicates the need to prepare professionals for different types of work and to have profiles according to specific functions in the use of digital services. According to the ESD28, health professionals and managers of digital health initiatives need training that covers everything from technological aspects to strategic skills and mastery of areas such as information systems, data management, security, privacy, strategy, financing, and regulation, in order to keep up with technological transformations and contribute to quality care and effective digital health management (MS, 2020).

For some years now, the ICT in Health survey has been investigating capacity-building strategies and training in health informatics by facility managers and professionals in the field. And, in view of the context of the expansion of digital health in the country, in 2024 the survey began to investigate this issue in greater depth. The choice of competencies investigated by the survey was based on the results of the workshop held during the 2022 Brazilian Congress of Health Informatics (CBIS), in which the competencies in health informatics for professionals working in the area, either directly or indirectly, were assessed and validated (Gaspar et al., 2024).

In the case of the indicators related to healthcare facility managers, the topics are focused on process, system, resource, and risk management activities, while in the case of physicians and nurses, they are linked to clinical practice mediated by the use of technologies, data analysis, and patient-centered technologies. Bearing in mind that the field of health informatics has a wide range of topics and different levels for each type of use, 10 of the main ones were chosen to be investigated by the survey.

With regard to training related to health informatics, the results indicated that in the 12 months prior to the survey, around half of the managers interviewed had done some kind of learning in this area: 37% had done training or capacity-building, 10% specialization, 1% had a master's degree, and 3% took some other type of course or capacity-building in the area. A higher percentage of public facility managers (41%) had undergone training or capacity-building compared to those in private facilities (33%). Among the types of facilities, both PHU (44%) and inpatient facilities with more than 50 beds (49%) had a higher proportion of managers who had undergone training in this area. It should be noted that the managers of inpatient facilities with more than 50 beds underwent the most training in health informatics, mainly at the specialization (16%) and master's (3%) levels.

For the total number of facilities, the topics most covered in the training were the structure and function of health services organizations (67%) and interdisciplinary team management (65%). Next, topics such as resource management, risk management, and health policies and regulatory frameworks were studied by approximately half of the managers who underwent training in health informatics. On the other hand, studies of network architectures and topologies (26%) and business alignment (23%) were carried out by a smaller percentage of managers.

There were some differences by type of facility, with around eight out of ten PHU managers studying the structure and function of health services organizations, while the other types presented lower percentages (Chart 19). On the other hand, topics such as systems governance, project management, cloud computing, and network architectures and topologies were studied more by managers of inpatient facilities with more than 50 beds. It can be inferred that programs such as those run by the Digital Health and Information Secretariat (Seidigi) have stimulated public managers, as has the Support Program for Institutional Development of the Brazilian Unified Health System (Proadi-SUS), which, with the support of private hospitals and those chosen as having the highest quality, have offered short courses or certificate specialization courses. Private hospitals, on the other hand, need to invest more in their own employees by organizing in-house courses or encouraging them to seek training at academic institutes or universities.

CHART 19

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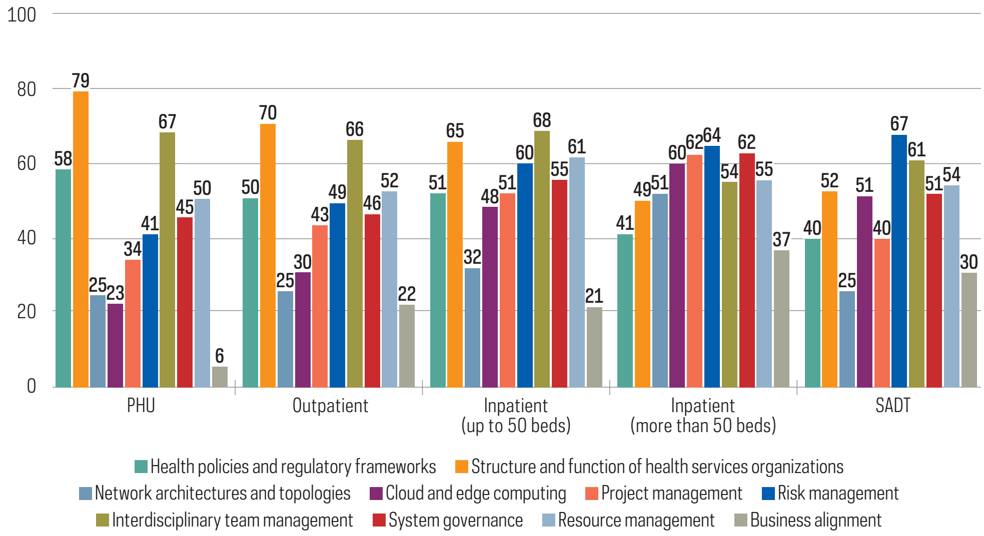
Managers by topics of health informatics training carried out (2024)

Total number of managers who carried out training in health informatics (%)



With regard to professionals in the field, 23% of physicians and nurses had undergone some kind of training in health informatics in the 12 months prior to the survey. With regard to nurses, 26% of those working in private facilities and 21% of those in public facilities had undergone this type of training. Furthermore, this percentage increased with age: 13% of those up to 30 years old, 24% for those 31 to 40 years old, and 27% of those 41 years old and older.

Among physicians, the profile of those who carried out this training varied, as there was a higher percentage of those working in public facilities (29%) compared to those working in private ones (19%). There were also differences by age group, with 23% of those up to 35 years old, 16% of those 36 to 50 years old, and 40% of those 51 years old or older having taken a course or training in health informatics.

As for the topics studied, the main ones were patient safety, ethics, security and privacy, data and information analysis, and person-centered care. For both physicians and nurses, there were variations in relation to the type of facility, which may be associated with the type of health service provided, as shown in Charts 20 and 21.

It is noteworthy that, in the case of nurses, topics such as data quality, data and information analysis, and classifications, vocabularies and terminologies were more studied by them in inpatient facilities. With regard to physicians, greater variations were observed between the types of facilities. Topics such as health determinants, clinical decision support, and precision medicine were more in demand by physicians from PHU, outpatient facilities, and inpatient facilities with up to 50 beds, while classifications, vocabularies, and terminologies were studied by almost all those working in inpatient facilities with more than 50 beds. These variations may be a reflection of the categories of technology adopted and the type of care provided according to the levels of care, since inpatient facilities adopted more digital technologies and collected and used data such as Big Data, IoT, and AI, which requires greater knowledge of the subject among their professionals.

CHART 20

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Nurses by topics of health informatics training carried out (2024)

Total number of nurses who carried out training in health informatics (%)

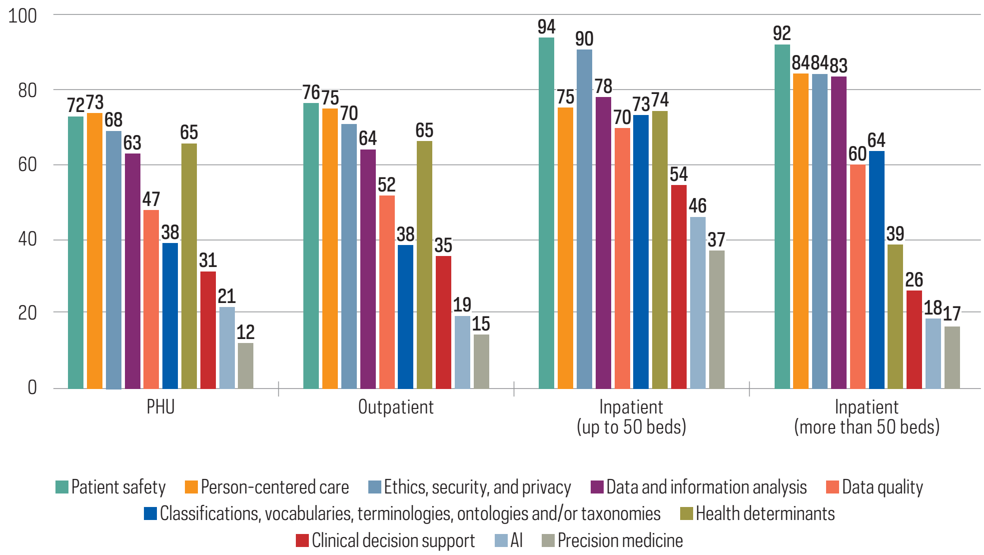

CHART 21

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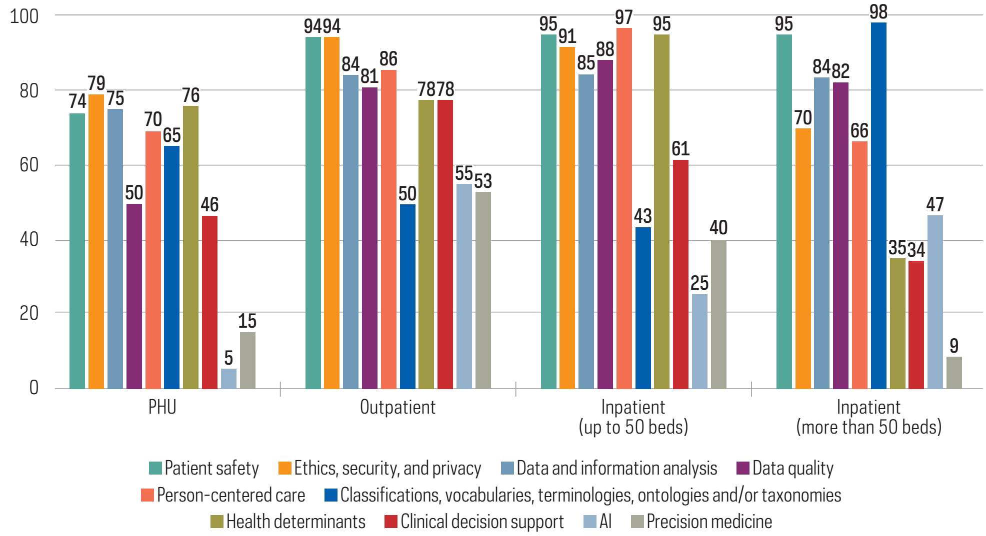
Physicians by topics of health informatics training carried out (2024)

Total number of physicians who carried out training in health informatics (%)



The results of this edition of the survey indicated the need to draw up policies aimed at training professionals who acquire competencies in health informatics and master areas of knowledge such as information systems, data management, security, and privacy, in order to guarantee effective and safe care. In addition, health informatics offers opportunities for research and innovation, including the use of AI and Big Data for data analysis and the development of clinical decision support systems. Continuous training allows professionals to keep up with technological changes, strengthening their integration into digital health initiatives and contributing to quality care. This highlights the importance of formulating public policies that contribute to improve understanding of digital health and ensure that its possibilities are encouraged in practice, considering the exponential growth in the use of ICT in care, education, and research environments, and its potential to improve care and expand access to services (Araújo et al., 2023).

Final considerations: Agenda for public policies

The results of the 11th edition of the ICT in Health 2024 survey, based on information collected from managers, physicians, and nurses in Brazilian healthcare facilities between February and August 2024, showed that the adoption of digital technologies in health care has advanced in the country, achieving universal use of computers and Internet access in healthcare facilities and by physicians and nurses. Another transformation was the use of electronic systems to record patient information, especially in PHU and inpatient facilities with more than 50 beds. This was reflected in the availability of patient data in electronic format, an important factor both for tracking a specific patient's journey and for monitoring the population's health.

However, some challenges remain for the advancement of digital health. These include the allocation of resources for IT investment, the expansion of online services offered to patients, the adoption of emerging technologies such as Big Data analytics and AI in healthcare facilities, and the greater availability of telehealth in facilities and its appropriation by healthcare professionals.

Other gaps include training managers and professionals in health informatics and expanding the content covered. The lack of adequate training in the use of technology can generate insecurity and resistance that make it difficult to adapt to the digital model. To overcome these barriers, it is necessary to invest in continuous training, expand technological infrastructure, develop institutional protocols and guidelines on the development and adoption of digital technologies, especially the use of AI, which will enable a greater understanding of how they work and provide greater safety in their use for professionals in the field.. It is important that coordinated actions and sustainable investments are made so that public digital health policies promote equitable and universal access to health.

In view of the results presented in this edition of ICT in Health, it is important to promote public policies that prioritize funding for technological infrastructure, guaranteeing quality connectivity and interoperability between health information systems. With regard to telehealth, much progress has been made, but it is important that its expansion be accompanied by incentives for the adoption of these solutions, especially in less digitalized regions. Finally, digital health governance must ensure that technological innovations result in concrete improvements in access to and quality of health services.

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Articles

Assessment of digital health information systems[1]

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The medical informatics discipline was initially named during the late 1980s. The term "health informatics" became more popular and was recognized worldwide as a strategic term to cover all healthcare disciplines after 1990. Most countries adopted this term; however, the United States adopted the term "biomedical informatics," defining it as "the interdisciplinary field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problems solving, and decision making, driven by efforts to improve human health" (Shortliffe et al., 2021, p. 25).

WHO recognized the importance of technology to improve healthcare delivery and evolved the field accordingly. The WHO Global Observatory for eHealth survey of Member States in 2015 documented the rise in adoption of eHealth in countries. The document highlighted those countries that had national eHealth strategies, representing the beginning of a shift from an unsustainable project-based approach towards a systematic, integrated approach designed for cost-effective investment and alignment of partners. The WHO Executive Board meeting emphasized the spread of information and communication technologies (ICT) with significant interconnectivity to accelerate progress towards achieving universal health coverage, ensuring access to quality essential health services (eHealth and mHealth) (WHO, 2016).

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Later, the term "digital health" was introduced as "a term encompassing eHealth (which includes mHealth), as well as emerging areas, such as the use of advanced computing sciences in 'big data,' genomics and artificial intelligence" (WHO, 2019, p. 1). WHO adopted the digital health, defining it as the use of digital technologies for health, employing routine and innovative forms of ICT to address health needs. It emphasizes that this term is rooted in eHealth, which is defined as "the use of information and communications technology in support of health and health-related fields." (World Health Assembly [WHA], 2018, p. 2).

Also, in 2018, the WHO launched the 71st General Assembly and, among several recommendations, the organization urged country members to:

> Assess their use of digital technologies for health, including in health information systems at the national and subnational levels, in order to identify areas of improvement, and to prioritize, as appropriate, the development, evaluation, implementation, scale-up and greater utilization of digital technologies, as a means of promoting equitable, affordable and universal access to health for all, including the special needs of groups that are vulnerable in the context of digital health. (WHA, 2018, p. 2)

Along with the recommendations, countries should assess the situation of ICT in healthcare. Thus, in 2021, the WHO also made available the Global Strategy for Digital Health. The main objective was to support country members to improve global health through the adoption of digital health solutions using health data to promote health and well-being (WHO, 2021). A report published in 2023 on the ongoing journey to commitment and transformation of digital health in the WHO European Region acknowledges the inadequate evaluation of the impacts of digital health interventions. For example, only 15% of responding Member States reported the evaluation of government-sponsored mHealth programs and only 37% of Member States reported that a telehealth service in their country had been evaluated. Consequently, WHO is recommending the development of robust national evaluation guidelines and the implementation of systematic monitoring and evaluation to monitor the impact of digital health interventions and ensure evidence-based approaches to digital health development (WHO, 2023).

The current achievements in digital health and the development of technology and health informatics science motivated organizations across the world to understand how important it is to create scenarios that make the adoption of new resources available. However, to design systems for the guidance of ICT adoption, it is necessary to analyze the baseline and/or progress status to plan the implementation and development of digital transformation (Johnston, 2017). Initial assessments support decisions regarding improvements and indicate the readiness of national systems or individual organizations to integrate new technologies to enhance healthcare delivery.

Therefore, the evaluation of maturity represents a tool for the evolution and prioritization of actions, considering a methodological, structured, and transparent model for setting the priorities for promoting equitable, affordable, and universal access to healthcare. In fact, evaluation is not simple; many decisions must be made before the process begins. The literature presents several models, frameworks, and types of content that can bring summative and formative values to help organizations enhance their use and development of digital health to achieve optimal results from ICT and conduct studies to expand its use even more as continuous improvement causes a positive impact in healthcare delivery and the health status of the population. In view of the above, the aim of the current article is to present a brief discussion of possible considerations and evaluation models for digital health information systems, highlighting the importance of evaluating digital health interventions.

DIGITAL HEALTH MATURITY MODELS

A maturity model is a set of structured levels that describe organizational behaviors, practices, and processes that reliably and sustainably produce required outcomes. It measures the ability of an organization to continuously improve in specific dimensions until it reaches the desired level of maturity (Carvalho et al., 2016).

Frequently, maturity models are based on premises that include all the players involved in the healthcare system, such as personnel, infrastructure, processes, and financial and technology resources. Consequently, several models are available in the literature covering different areas of ICT implementation. However, most existing evaluation models focus on technical problems rather than seeing the topic as a phenomenon that is set in a specific context (Yusof et al., 2008). Consequently, it is possible to obtain weak or incomplete evaluations, which poses greater challenges for designing future implementation.

As Ammenwerth et al. (2003) emphasized, although there are several models available to support the evaluation of maturity in health information systems, many other questions must be considered, such as the complexity of the systems, lack of clarity, the influence of user expectations, and the motivations for evaluation. This can also be a reminder that systems are formed by humans. The way they interact with technology will have a significant effect on success in fostering willingness within facilities to adopt and use resources in their daily work.

Due to these factors, Pettigrew (1985) developed a framework called CCP—content, context, and progress. The initial idea was to study organizational change, but Symons (1991) applied the framework to the evaluation information systems. The framework provides a holistic approach that incorporates the content, context, and process of evaluations.

Specifically, "content" refers to the specific area of transformation under evaluation: What should be measured? Most of the time, this is a complex question that requires information about the technical aspects and the social and behavioral aspects of the users and how they interact with the system; it involves external and internal conditions of the organization such as economics, the structural environment, usability, user participation, and outcomes for patients (Ammenwerth et al., 2003). "Context" refers to a dynamic multi-level process that includes social, political, and cultural values, which explains why, most of the time, systems for commercial purposes do not succeed in the healthcare area (Nguyen et al., 2014). "Process" may be understood as the actions, reactions, and interactions of the parties who are attempting to move the organization from one state to another (Pettigrew, 1987).

The history of health informatics shows that François Grémy (Degoulet et al., 2005), who is one of the founders of health informatics and the one who gave the discipline its name (*informatique médicale*), proposed a framework in which the role of humans and their subjectivity was highlighted in a five-step evaluation process. The five steps proposed by Grémy et al. (1999) were: conception, program preparation, machine execution, program output, and overall impact. With several limitations, this proposal was highly focused on the development of the cycle of systems. The most interesting item to note is that since the beginning of the area as a discipline, the understanding of the importance of evaluating systems to achieve progress and measure impact was already present in academic studies. Thus, in the conclusion, the authors led by Grémy emphasized:

> In any (health) information system the human project manager as well as the designers and the users are part of the system. Evaluation must consider their feelings, reactions and behavior. Evaluation of information systems is a vane enterprise, if the human factors are not central to the evaluation process. (Grémy et al., 1999, p. 21)

While Grémy et al. (1999) focused-on system development, the literature includes other models based on evaluations that are focused on: user willingness to adopt ICT; on a general basis; the integration of social determinants into electronic health systems; and the Sustainable Development Goals (SDG) developed by WHO, highlighting the importance of governance (van den Berg et al., 2017).

There have been other pioneers in studies of evaluation. Friedman and Wyatt (2006) developed a framework including four objective approaches (comparison-based, objective-based, decision-facilitation, and goal-free) and four subjective approaches (quasi-legal, art criticism, professional review, and responsive/illuminative).

Neame et al. (2020) conducted a systematic review of evaluation of health information technologies. The authors emphasized what is already common sense in the field: most frameworks were developed for use in specific healthcare settings such as hospitals, mobile technology, health information exchanges, and electronic health records.

The vision provided by the review above highlights the frameworks developed by the Healthcare Information and Management Systems Society (HIMSS). They are probably the most-used models in the world, as HIMSS is a global society focused on operations and maturity models, reinforcing the challenge of developing a single model that can cover all aspects of healthcare organizations. Most of its models are based on eight evolution phases or stages that measure the degree of maturity of the system and what can be done to improve and move to the next stage. As expected, HIMSS models are dedicated to specific areas of health care. There is no consensus on a single model for digitizing health information systems that can be used as a basis for a country (HIMSS, 2024). The Electronic Medical Record Adoption Model (Emram) is one of the most-used models, incorporating methodology and algorithms to automatically score hospitals and providing strategies for IT alignment and opportunities for improvement across organizations (Gomes & Romão, 2018).

Final considerations

The evaluation of digital health information systems is a complex process that requires consideration of various technical, social, and behavioral aspects within the organizational context. Depending on the setting and objectives, it is important to consider a holistic approach to digital health evaluation, including factors such as evaluation processes, human factors, etc.

Digital health intervention evaluation can offer both objective and subjective approaches, providing a comprehensive perspective on evaluation methodologies. However, different evaluation frameworks and models should be considered that are tailored to specific healthcare settings. This shows the complexity and diversity of digital health information systems and digital health.

In conclusion, despite the extensive development of digital health intervention evaluation models, there is no consensus on a single, universal framework for the evaluation of health information systems. This shows the ongoing challenges and opportunities in the digital health domain. Assessing the impact of digital health is important and instrumental in achieving optimal outcomes in healthcare delivery and improving public health.

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Algorithmic generalization in digital health: Challenges for integrated health in different Brazilian regions

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In the near future, Brazil is expected to integrate its health databases, bringing together information on patients treated in all the hospitals of its five regions, from the most urbanized to those most remote in the country, with standardized and homogenized data collection and storage procedures. In this scenario, machine learning algorithms will be able to learn from a large amount of data, taking advantage of the diversity and similarities of patients' clinical conditions to predict various types of diseases.

These algorithms will help health professionals to make better decisions, facilitate faster diagnoses, and offer further assertive prognoses for new patients. Provided with integrated data, efficient algorithms, and healthcare teams trained to interpret them, it will be possible to offer every patient quality health care, available in all regions of the country on an equal basis.

Medical records are becoming increasingly automated and generating a large amount of information about patients. This scenario, however, is still far from being a reality for several reasons, such as the need to anonymize patients, differences between regions and hospitals in terms of the availability and quality of resources, and differences in care protocols, training of professionals, and user profiles.

One of the main challenges is maintaining the privacy of patients' personal information. The sharing of information must ensure anonymization in accordance with the Brazilian General Data Protection Law—LGPD (Law No. 13.709/2018). The data collected from patients is intended to show an overview of their health and guide their treatment. In addition to this main purpose, this data, added to that of many other patients, can help find patterns related to diseases, as well as support educational campaigns and the design of strategies to optimize the allocation of resources.

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Ensuring patients' right to privacy will be increasingly important, but it is also necessary to raise awareness of the need to contribute to the advancement of knowledge as health science evolves based on evidence and data. The requirement to anonymize patient data, despite being necessary, makes the task of handling and structuring a unified database much more complex.

Another major challenge is homogenizing data. There are many possible data formats in the health sector, which can come from electronic records, tabular records, images, videos, and other sources. The same clinical characteristic can be measured using different units of measurement and equipment, with varying degrees of precision. A robust, standardized database only becomes viable with the collaboration of professionals from different areas, such as the specialists who request the tests, those who collect them, the ones who store them, data scientists, and technologists.

Equally important is the involvement of the proponents of guidelines and public policies. Although it may seem like a technical task to collect, store, and analyze data, the desired scenario poses a fundamental problem, which is to equalize the different regions and hospitals in Brazil with the same resources, avoiding the distortions that still exist and generate inequalities in access to health care. Standardizing the data quality across different regions of the country will ensure an equitable health system.

There is also a conceptual issue to consider. By increasing the volume of data, we also increase the diversity and possibilities of developing algorithms that learn more and better about all the nuances of diseases. However, increasing the amount of information also creates a risk of adding more noise, which can come from many sources, such as measurement errors, inconsistencies, inaccuracies, etc. In addition, the same variables measured in different locations can show changes in their distributions, which can have an impact on the training of machine learning algorithms.

A recent study tested different data aggregation strategies from several Brazilian hospitals to predict COVID-19-related mortality and found that instead of increasing the predictive capacity of locally developed algorithms for most hospitals, data aggregation decreased this capacity (Wichmann et al., 2023). The cost-benefit of aggregating data from different regions and hospitals to increase sample size must be weighed.

Although it is not yet possible to achieve the scenario of a single integrated health database, other paths are being taken to make the health system more intelligent and inclusive. Algorithm developers are continuously researching solutions to improve healthcare decisions. One possible analysis approach is to train prediction algorithms in a given location with greater data availability, which can later be generalizable to other locations, i.e., can be adaptable without the need for major changes while maintaining a good predictive capacity. Algorithmic generalization seems to be a more realistic solution at the moment for obtaining good results in different Brazilian regions and varied clinical scenarios.

Generalizable algorithms

The application of machine learning algorithms has transformative potential in the health sector. This is an area of Artificial Intelligence (AI) that combines statistical models with computer algorithms to learn complex patterns in data and incorporate the interactions of multiple predictors, thereby refining predictions of events of interest (Geron, 2021). Clinical records and image data, among other data formats, can be used to train machine learning algorithms to find these complex patterns.

When training an algorithm, the available data is often divided into two parts, known as training and testing. In the first part, the algorithm learns the complex interactions between the predictors and the outcome of interest, and in the second part, the algorithm is tested on new examples. This is the first effort to assess whether the results obtained in training can be generalized to new data.

The strategy of dividing the data into sub-samples can be extended using a method called cross-validation, in which several partitions are made, repeating this training process on part of the data and testing the same algorithm on the examples not used in the training process. This technique can also be used repeatedly to ensure greater diversity in the training data and ensure that the good performance obtained is not just the result of a single partition of the data (Geron, 2021). It is important to note that traditional machine learning makes use of the fact that the predictors used in training and testing are the same and come from the same distribution, but it is not always possible to ensure this correspondence when the aim is to transfer learning from one place to another.

Transfer learning

The challenge is greater when considering the generalization of an algorithm trained in one source location to be applied in another target location. For this purpose, it is possible to use the transfer learning method (Pan & Yang, 2010), which is an important tool for contexts in which obtaining new data in a given location is costly or difficult to access. Transfer learning makes it possible to take advantage of knowledge previously acquired at the source location to start training and speed up the development of the model at a target location (Figure 1).

FIGURE 1

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Scheme representing transfer learning from a region with a large volume of data to a region with little data

Source: prepared by the authors.

In the context of transfer learning, it is desirable that the source data, on which the algorithm will be pre-trained, has a correspondence with the target data, where it will be used (Pan & Yang, 2010). If the predictors in the source data have very different distributions from the target data, further adjustments and adaptations will be required (Weiss et al., 2016) and may even jeopardize the target site model.

An example of the application of this method is the identification or classification of images. This task is commonly performed with deep neural networks, a method that uses multiple interconnected regressions applied in several layers. The weights (or parameters of the regressions) are adjusted in such a way as to improve the predictions. The various layers capture different characteristics of the images. In transfer learning, the first layers of the network are pre-trained with a large volume of images to detect general aspects such as lines, corners, edges, geometric shapes, and other simpler patterns, while the last layers are left free for fine-tuning the images. The fine-tuning process requires comparatively less data and fewer computational resources than a starting analysis (Ni et al., 2024; Sarkar et al., 2018). To apply the transfer of this learning to a new set of images, the pre-trained models are shared by means of millions of neural network parameters and weights, previously obtained with a large volume of images (Sarkar et al., 2018).

Based on this example, it is easy to visualize an application in the medical field, such as for the detection of diseases in imaging scans. In a hospital where the availability of an imaging exam is limited, fine-tuning a pre-trained algorithm can make it possible to obtain robust predictions with little new data available, taking advantage of knowledge acquired in other scenarios where the exam is more accessible. Transfer learning is, therefore, particularly interesting for hospitals with limited financial resources.

It is possible to apply transfer learning in other contexts in the health area that involve other types of data besides images, such as tabular data in which the outcome is known. An example would be training an algorithm for supervised data with the aim of predicting a certain outcome of interest in a region of the country with a large database, and the model obtained being reused as a starting point for training in another region with little data.

The predictive performance of transfer learning in health care depends on the quality and quantity of the source data and the similarity between the source and target data. When these conditions are met, transfer learning can result in more robust and generalizable models than those trained only with locally available data.

This is particularly relevant in areas where collecting new data is expensive or time-consuming. For example, in studies regarding rare diseases, data collected over the course of a few decades can be used to train models, which are then adjusted with more recent and specific data from new patients, allowing for faster and more accurate diagnoses.

Another promising application of transfer learning in health care is in natural language analysis for processing electronic medical records. Pre-trained language models with large amounts of text from these records can be adjusted for specific tasks, such as identifying patterns in diagnoses or predicting treatment outcomes. This not only reduces the time and costs involved in training the model but also improves the accuracy and relevance of the results, facilitating more informed clinical decision-making.

In the context of disease prediction through the use of the Internet of Things (IoT), transfer learning can also be used to predict the onset of chronic conditions. Continuous monitoring devices and sensors generate huge amounts of data about patients' health. This data can be used to train models that are then adjusted to predict the progression of diseases in patients with limited monitoring history, allowing for early and personalized interventions.

In medical education, transfer learning can also be applied to customize training and professional development programs. Pre-trained models with academic and clinical performance data from a wide variety of students and healthcare professionals can be tailored to specific institutions or regions, helping to identify each student's strengths and weaknesses. This can result in personalized study plans that maximize learning and improve the clinical competence of these future professionals.

Finally, transfer learning can also be beneficial in treatment and drug research. Models trained with large volumes of data from clinical trials in diverse populations can be adapted to predict the effectiveness of new treatments in specific populations. This allows pharmaceutical enterprises to develop more effective and customized drugs, allocating resources more efficiently and improving patient outcomes.

Differences between source and target data in transfer learning

The difference between the distributions in the training and test data, or in the source and target data, in the context of transfer learning is called data shift and can occur in different ways. Data shift is the main challenge for algorithmic generalization and can occur due to regional changes and demographic characteristics, changes in guidelines and practices, and temporal changes (Guo et al., 2021).

A label shift is defined when there is a difference only in the distribution of the outcome studied, but the distribution of the predictors remains the same. Covariate shift occurs when there is a difference in the distribution of the predictors, but the relationship between them and the outcome remains the same. Finally, concept shift occurs when the relationship between the predictors and the outcome changes over time, commonly observed in time series and long follow-up studies.

An example of a label shift would be if an algorithm has been trained to predict hypertension in a large, urbanized city, and the knowledge acquired is intended to be applied to another city with the same size and urbanization characteristics, but with a population that has a genetic predisposition to a cardiovascular disease that increases the risk of developing hypertension. In this case, the distribution of the hypertension outcome will be different, and the algorithm trained in the city of origin may underestimate the probability of having hypertension in the target city.

An example of a covariate shift is an algorithm that has been trained to predict hypertension in a city whose lifestyle is influenced by a lack of access to healthy, fresh food and few spaces for physical activity. The algorithm trained in this city will then be transferred to another city where eating habits are different, with a greater abundance of fresh food and more spaces dedicated to physical activity. In this case, the predictors of hypertension, diet quality, and physical activity will have different distributions in the two cities; however, the relationship with hypertension is expected to show the same trend in both places.

To illustrate the concept shift, an example would be an algorithm that has been trained to predict a seasonal respiratory disease, based on clinical symptoms. The following season, a new vaccination campaign takes place, and the respiratory disease changes its characteristics, appearing less frequently and with milder symptoms, different from the previous year. In this case, the previous year's algorithm will make predictions that may not reflect the new reality, since the concept of outcome has changed.

In the context of transfer learning from one region to another, to ensure that the algorithm trained in the place of origin continues to have good predictive performance in the target location, it is important to investigate whether any type of data shift occurs. When identified, it may be necessary to apply corrections and weightings to adapt the algorithm trained in the first city to apply it in the second. In some situations, it may be necessary to retrain the algorithm with more updated data to correct distortions in the predictions.

Conclusion

The progress made in recent years with machine learning algorithms, a growing area of AI, has boosted research and applications in health. Algorithmic generalization stands out as a possibility to help correct the inequalities that are perpetuated in the different regions of Brazil. It is a strategy that can help the most remote locations, with few technological resources, to make better health decisions. AI requires specific knowledge and complex methodologies to adapt algorithms according to changes in data distributions and relationships between variables. However, while algorithmic generalization is an efficient and transformative strategy, it must be complemented by a focus on integrated and equitable health care.

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Precision oncology's path in low- and middle-income countries: From challenge to opportunity using medical informatics

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The global cancer care landscape reveals significant disparities between high-income countries (HICs) and low- and middle-income countries (LMICs) (Rathnasamy et al., 2021; Stefan & Tang, 2023). Over 70% of cancer deaths occur in LMICs despite representing only 60% of the global population (Sung et al., 2021). Five-year breast cancer survival rates exceed 80% in HICs but fall below 40% in many low-income countries (Bazargani et al., 2015). While 90% of HICs have comprehensive cancer treatment services, less than 15% of low-income countries do (World Health Organization [WHO], 2022). Advanced technologies like laparoscopy and robotics are standard in HICs but not in developing countries (Beddoe et al., 2016). With 75% of cancer deaths expected in LMICs in the next decade (Cancer Research UK, 2022), implementing precision oncology is crucial (Gopal, 2023).

Precision oncology uses genomic, proteomic, and multi-omic data for personalized treatment strategies (D'Souza & Saranath, 2017; Prasad et al., 2016). It has improved treatment efficacy and reduced toxicities in HICs (Luis & Seo, 2021). The field has evolved from focusing solely on genomics (Lu et al., 2017; Shin et al., 2017) to include proteomic (Rodriguez & Pennington, 2018) and multi-omic approaches (Nicora et al., 2020). Recent advancements have revealed limitations in using genomic data alone (Aldea et al., 2023).

Implementing precision oncology in LMICs is crucial due to projected cancer rate increases of 81% by 2040, compared to 40% in HICs (International Agency for Research on Cancer [IARC], 2024; WHO, 2020). This surge is driven by population growth, aging, and cancer-associated lifestyle factors. Precision oncology could optimize limited resources, potentially providing more cost-efficient care by identifying the most effective treatments based on genetic profiles.

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The implementation of precision oncology could catalyze broader improvements in cancer care infrastructure, including the development of biobanks, molecular laboratories, and bioinformatics capabilities (Department of Health Research of the Government of India [DHR], n.d.). This approach offers a path towards more equitable global cancer control, potentially saving millions of lives and reducing the economic burden of cancer in vulnerable regions. However, scaling these advancements globally, especially in resource-constrained settings, remains a challenge.

Platforms for precision oncology

PROJECT GENIE

Project GENIE, spearheaded by the American Association for Cancer Research (AACR), is revolutionizing cancer research through collaborative data sharing.[3] By aggregating and harmonizing clinical-grade cancer genomic data from global institutions, it creates a comprehensive, accessible repository that empowers researchers to explore cancer complexities, identify new therapeutic targets, and accelerate personalized medicine development. As of 2022, Project GENIE had compiled data from over 110,000 tumors, establishing itself as one of the world's largest publicly accessible repositories of clinically annotated genomic data (Pugh et al., 2022). The scale and diversity of this dataset enable robust analyses across a spectrum of cancers, including rare types and uncommon genetic variants, significantly advancing precision oncology.

THE CANCER GENOME ATLAS (TCGA)

The Cancer Genome Atlas (TCGA) stands out as a landmark achievement in cancer research, having comprehensively characterized the molecular profiles of over 20,000 primary cancers across 33 distinct cancer types (Ganini et al., 2021). This extensive program has produced a vast array of genomic, epigenomic, transcriptomic, and proteomic data, offering researchers an unparalleled resource for deciphering the molecular basis of cancer. TCGA's extensive dataset has significantly advanced our understanding of cancer biology and aided in identifying crucial diagnostic and prognostic biomarkers, thus accelerating the development of targeted therapies. The enduring impact of TCGA continues to influence cancer research, providing a solid foundation for future discoveries in precision oncology. Importantly, a comparative study between TCGA and the real-world GENIE registry demonstrated a general agreement in gene-level mutation frequencies, validating both datasets' robustness and clinical relevance (Kaur et al., 2019).

[3] More information about the project at https://www.aacr.org/professionals/research/aacr-project-genie/

POND4KIDS AND CURE4KIDS

The Pediatric Oncology Networked Database, POND4Kids, exemplifies an innovative web-based platform designed to improve pediatric oncology care in resource-constrained environments (Quintana et al., 2013). This system enables oncologists to collect, share, and analyze clinical data, facilitating informed treatment decisions, outcome evaluations, and collaborative research. Complementing POND4Kids is Cure4Kids (Quintana, 2008; Richardson et al., 2014), a comprehensive educational and collaborative platform for healthcare professionals in pediatric oncology. Through virtual meeting rooms, document-sharing capabilities, and educational resources, Cure4Kids promotes knowledge exchange and international collaboration, ultimately leading to enhanced patient outcomes.

ALICANTO CLOUD

Alicanto Cloud (Quintana et al., 2022) is an innovative online collaboration platform designed to overcome global health challenges and COVID-19 pandemic-induced limitations on in-person interactions. This platform accelerates learning health system collaborations by facilitating communication, education, and knowledge management among diverse stakeholders and experts worldwide. Alicanto offers tools for both synchronous and asynchronous discussions, enabling healthcare professionals to share educational resources, discuss complex cases, and standardize care guidelines across institutions and countries. Its success in online training, virtual tumor boards, and knowledge management has led to its implementation in various healthcare fields, including cancer, pediatrics, and diabetes. Notable applications include the use of Alicanto by the Beth Israel Deaconess Medical Center (Boston, Harvard Medical School) to connect 13 hospitals and conduct over 600 virtual tumor board case discussions and the use of the platform by Dana-Farber Cancer Institute (Boston) as an online cancer training network for sub-Saharan Africa.

THE COMPREHENSIVE CANCER CENTER IN THE CLOUD

The Comprehensive Cancer Center in the Cloud (C4) is a groundbreaking initiative designed to harness cloud computing and Artificial Intelligence (AI) to tackle cancer health disparities and enhance care access for underserved communities (Ngwa et al., 2024). C4's innovative approach involves creating health access hubs within religious organizations that are equipped with advanced technological infrastructure to bridge the gap between healthcare providers and marginalized populations. Integrating AI-powered tools like chatbots and telehealth support amplifies the platform's capabilities, facilitating remote consultations, personalized interventions, and improved patient engagement. With its multilevel, community-oriented strategy and emphasis on cultural competency and spiritual care, C4 presents a promising model for achieving health equity in cancer care.

Challenges to implement precision oncology in LMICs

ECONOMIC AND FINANCIAL CONSTRAINTS

Economic and financial constraints significantly challenge the implementation of precision oncology in LMICs, with advanced technologies straining limited healthcare budgets (Tan et al., 2018). LMICs often prioritize basic healthcare over advanced cancer diagnostics (Kodali, 2023), while exorbitant drug prices hinder access to appropriate therapies, exemplified by the cost of trastuzumab in sub-Saharan Africa (Gershon et al., 2019). The limited availability of approved drugs and socioeconomic factors further reduce the likelihood of cancer screening (Akinyemiju, 2012). Addressing these disparities requires improving access to health centers, incentivizing routine check-ups, and enhancing non-profit healthcare quality to extend precision oncology interventions to financially constrained populations.

INFRASTRUCTURE GAPS

Implementing precision oncology in LMICs faces significant infrastructure challenges, requiring vast multi-modal data (Subbiah, 2023) and robust systems often absent in these regions. Key gaps include a lack of well-equipped molecular pathology laboratories (DHR, n.d.), a shortage of trained personnel (Stefan & Tang, 2023), and inadequate cancer registries. High-quality population-based cancer registries cover only 2% of Africa and 6% of Asia, compared to 83% of North America (Piñeros et al., 2017), hampering efforts to understand cancer patterns, guide research, and inform policy. LMICs also often lack sufficient data management and analysis capabilities (Mulder et al., 2017).

Data sharing and standardization are crucial for advancing global precision oncology. Initiatives like the International Cancer Proteogenomic Consortium (ICPC) promote global collaboration and standardized data models.[4] Federated data-sharing approaches offer promising solutions, allowing institutions to control their data while participating in large-scale analyses (Mahon et al., 2024). These efforts are essential for accelerating research, improving patient outcomes, and ensuring LMICs can benefit from and contribute to global advancements in cancer care.

CULTURAL AND PSYCHOSOCIAL BARRIERS

Implementing precision oncology in LMICs faces significant cultural and psychosocial barriers alongside economic and infrastructure challenges. Cancer stigma, traditional beliefs, and lack of awareness contribute to late-stage diagnoses and reluctance to seek medical care. The complexity of precision oncology further complicates communication in communities with low health literacy. Community health workers (CHWs) are crucial in bridging these gaps, with mobile technologies and mHealth applications supporting their efforts to improve early detection rates (Schliemann et al., 2022). Addressing these

[4] More information at https://proteomics.cancer.gov/programs/international-cancer-proteogenome-consortium

barriers requires a multifaceted approach combining education, community engagement, and culturally sensitive healthcare delivery, which, when tackled alongside economic and infrastructure challenges, can help realize the true potential of precision oncology in LMICs.

Strategies for overcoming barriers in LMICs

The implementation of precision oncology in Low- and Middle-Income Countries (LMICs) faces numerous challenges, but innovative strategies are emerging to overcome these barriers. By developing cost-effective solutions, strengthening healthcare infrastructure, improving drug access, enhancing education and training, and leveraging international collaborations, LMICs can make significant strides in advancing cancer care.

DEVELOPING COST-EFFECTIVE SOLUTIONS

One of the most promising approaches to implementing precision oncology in resource-limited settings involves tailoring diagnostic approaches to meet local needs and constraints. This strategy focuses on maximizing the impact of available resources while still providing valuable data for treatment planning. Smaller, more focused next-generation sequencing (NGS) panels can be designed to target specific, high-prevalent cancers in the region. At the same time, immunohistochemistry (IHC) and fluorescence in situ hybridization (FISH) offer cost-effective alternatives for identifying critical biomarkers and genetic alterations. Implementing a stratified approach, where patients undergo IHC or FISH testing before proceeding to NGS, can ensure efficient resource use. Encouraging local or regional production of diagnostic reagents and equipment through public-private partnerships can reduce costs. These tailored approaches allow LMICs to leverage precision oncology techniques within their resource constraints, potentially improving cancer care outcomes in these settings.

STRENGTHENING HEALTHCARE INFRASTRUCTURE

Developing robust healthcare infrastructure is crucial for successfully implementing precision oncology in LMICs. This multifaceted approach involves establishing molecular pathology laboratories, improving access to essential diagnostic tools like imaging equipment, enhancing cancer registries, developing biobanks, and improving laboratory quality assurance. Creating and equipping molecular pathology laboratories is essential for performing advanced diagnostic tests, requiring physical infrastructure, trained personnel, and quality control measures. Governments and healthcare systems should prioritize these labs, potentially starting with regional centers of excellence. Improving access to diagnostic tools may involve strategies such as mobile diagnostic units for rural areas or telemedicine solutions for remote image interpretation.

Comprehensive, up-to-date cancer registries are vital for understanding the cancer burden, planning resource allocation, and conducting research (Labkoff et al., 2024). LMICs should invest in digital health information systems to capture accurate cancer data across healthcare facilities, inform policy decisions, and help tailor precision oncology approaches to local needs. Establishing biobanks to store tumor samples and associated clinical data can significantly facilitate research and the development of locally relevant precision oncology approaches while enabling collaboration in international research. Implementing robust quality assurance programs for molecular testing, including participating in international proficiency testing programs and establishing national standards, is essential to ensure reliable results. While challenges remain, these approaches offer a path to improving cancer care and outcomes in resource-limited settings.

PATIENT ASSISTANCE AND DRUG ACCESS PROGRAMS

Improving access to expensive targeted therapies and immunotherapies is crucial for the success of precision oncology in LMICs. Strategies to address this challenge include expanding compassionate use programs, implementing tiered pricing models, encouraging the development of generic versions and biosimilars, and expediting their approval processes. Collaborations between governments, NGOs, and pharmaceutical companies can create sustainable models for drug access through public-private partnerships involving bulk purchasing agreements, technology transfer for local production, or innovative financing mechanisms. Establishing national or regional patient assistance programs can connect patients with available resources, including clinical trials and financial assistance. These combined approaches can significantly enhance access to crucial therapies in resource-limited settings, making precision oncology more feasible and effective in LMICs.

EDUCATION AND TRAINING

Continuous professional education is vital to improve expertise in precision oncology and advanced cancer therapies among healthcare providers in LMICs. This includes developing comprehensive training programs in molecular oncology, genomics, and precision medicine (Quintana, 2008), utilizing e-learning platforms for ongoing education (Quintana et al., 2013), and developing online courses with international experts (Richardson et al., 2014). Establishing fellowship programs, encouraging skill development, and promoting education in bioinformatics and epidemiology are crucial. Creating bioinformatics divisions at hospitals, emphasizing multidisciplinary approaches, and facilitating knowledge sharing through conferences and workshops can enhance collective expertise. These efforts aim to increase the number of specialists available to practice precision oncology, reduce physician burden, and improve localized cancer pattern recognition, ultimately enhancing the implementation of precision oncology in LMICs.

LEVERAGING INTERNATIONAL COLLABORATIONS

International partnerships between LMICs and HICs have proven to be one of the most effective means of improving cancer care. These collaborations facilitate knowledge exchange, and transfer information about best practices and cutting-edge research findings to LMICs while building local capacity through training healthcare professionals, supporting infrastructure development, and guiding precision oncology implementation. International research partnerships address LMIC-specific questions, such as identifying unique genetic variants and studying precision oncology effectiveness in diverse populations. Leveraging technology for remote consultations and sharing resources like bioinformatics pipelines and genetic variant databases enhances treatment decision-making and genomic data interpretation in LMICs. These partnerships improve cancer care quality in LMICs and contribute to the global understanding of cancer biology and treatment effectiveness across diverse populations.

Future directions

The landscape of precision oncology in LMICs is rapidly evolving, with emerging technologies, global collaborations, and policy changes shaping its future. As we look ahead, several key areas will play crucial roles in advancing cancer care and improving patient outcomes in resource-limited settings.

EMERGING TECHNOLOGIES

Emerging technologies have the potential to revolutionize precision oncology in LMICs, making advanced diagnostics and treatments more accessible and affordable. Liquid biopsies, a non-invasive technique for detecting circulating tumor DNA (ctDNA) in blood samples, could be a game-changer for LMICs (Aldea et al., 2023). This method offers a less expensive and more easily repeatable alternative to traditional tissue biopsies, enabling real-time treatment response monitoring and early recurrence detection. As the technology improves and costs decrease, liquid biopsies could become a cornerstone of cancer care in resource-limited settings.

AI and machine learning algorithms have immense potential in precision oncology (Nicora et al., 2020). In LMICs, AI could assist in interpreting complex genomic data, predicting treatment outcomes, and even aiding in cancer diagnosis through image analysis. These tools could help bridge the gap in expertise and resources, enabling more accurate and efficient cancer care.

Developing portable, low-cost diagnostic devices could bring molecular testing to remote areas in LMICs (Anandasabapathy et al., 2024). Combined with smartphone-based applications, these point-of-care diagnostic technologies could democratize access to precision diagnostics. By leveraging these emerging technologies, LMICs can potentially leapfrog traditional infrastructure limitations and provide more advanced, personalized cancer care to their populations.

OPPORTUNITIES FOR GLOBAL ONCOLOGY RESEARCH

Identifying novel cancer biomarkers is crucial for improving treatment decisions and patient outcomes in precision oncology, especially in LMIC populations (Luis & Seo, 2021). Ongoing research focuses on studying the genomic landscape of cancers in diverse ethnic groups and investigating unique environmental factors. Integrative genomic profiling has shown clinical benefits in advanced solid tumors (Cobain et al., 2021), while advances in splicing genomics provide insights into phenotypic stratification and biomarker identification (Francies et al., 2021). In LMICs, the role of infectious agents in cancer development is significant, requiring sophisticated bioinformatics infrastructure and expertise that are often scarce in these regions (Mulder et al., 2017). Studying genetic variations of cancer-causing viruses is essential for developing targeted prevention and treatment strategies (Oumeslakht et al., 2021).

The prevalence of inherited cancer syndromes varies significantly across populations (Helfand & Catalona, 2014), with conditions like Lynch syndrome showing considerable global variation (Abu-Ghazaleh et al., 2022). Research into inherited cancer syndromes associated with specific gene mutations, such as BAP1, is crucial for developing personalized treatment strategies (Walpole et al., 2018). The genetic landscape of cancer exhibits significant heterogeneity across populations, necessitating tailored precision oncology approaches (Mehrota et al., 2018). Studies have revealed significant inter-population differences in the frequency of variants like CYP2C8, involved in anticancer drug metabolism (Camara et al., 2024), and geographical variations in RET gene variants among patients with medullary thyroid cancer (Maciel & Maia, 2022).

Implementing precision oncology in LMICs, particularly in regions with high genetic diversity, presents unique challenges. Systematic meta-analyses and global assessments of gene association studies in various cancers are crucial for understanding the complex interplay between genetic variations and cancer risk (Montazeri et al., 2020). These studies contribute to developing more effective and targeted approaches in precision oncology for diverse populations in LMICs, addressing the specific genetic and environmental factors that influence cancer development and treatment response in these regions.

GLOBAL COLLABORATION AND EQUITY

International collaboration and data sharing are crucial for ensuring global equitable access to precision oncology. Expanding and replicating initiatives that foster partnerships between institutions in HICs and LMICs, such as the African Cancer Institute's collaborations, are essential. Creating global cancer genomics databases that include diverse populations is vital, as demonstrated by projects like the IARC TP53 Database, which has been used to understand brain tumor characteristics (Salnikova, 2014). While the International Cancer Genome Consortium (ICGC) closed in June 2024 (ICGC, 2024), similar initiatives could be developed to include data from LMICs, ensuring that precision oncology advances benefit all populations. Additionally, efforts to reduce the cost of genomic testing and targeted therapies through international agreements and bulk purchasing arrangements can help make these interventions more accessible in resource-limited settings.

GOVERNMENT POLICY AND ADVOCACY

Supportive policies and strong advocacy efforts are crucial for promoting investment in precision oncology research and infrastructure development in LMICs (Gopal, 2023). Governments in these countries should prioritize cancer care in their health policies, allocating resources for building molecular diagnostic capabilities and training specialized personnel. Advocacy groups can play a vital role in raising awareness about the importance of precision oncology and pushing for increased funding and support from national governments and international organizations. Policies that incentivize pharmaceutical companies to conduct clinical trials in LMICs and develop therapies for cancers prevalent in these regions are needed to ensure that precision oncology advances are accessible and relevant to diverse populations.

THE ROLE OF GLOBAL AGENCIES

The World Health Organization and other international bodies will play a crucial role in guiding the adoption of precision oncology in LMICs. WHO can expand its current efforts in standardizing cancer care practices to include guidelines for implementing precision oncology in resource-limited settings. International organizations can help establish ethical guidelines for genomic research and precision medicine applications in diverse populations. Additionally, global health agencies can facilitate knowledge transfer and capacity-building by creating platforms for sharing best practices and providing technical assistance to LMICs. These coordinated efforts will ensure precision oncology is implemented effectively and ethically in resource-constrained environments, ultimately improving cancer care outcomes in these regions.

DATA SHARING AND STANDARDIZATION

Developing robust data-sharing platforms, as promoted by initiatives like the ICPC, will be crucial for LMICs. Standardized data models and shared protocols will enable LMICs to participate in and benefit from global cancer research networks without requiring extensive local infrastructure. These platforms will facilitate international clinical trials, improving the quality and relevance of cancer research for LMIC populations. Efforts to harmonize electronic health records and cancer registries across countries will enhance the value of shared data for research and clinical applications.

ETHICAL CHALLENGES IN PRECISION MEDICINE

As precision oncology advances in LMICs, addressing the ethical challenges that arise is crucial. We must ensure that the benefits of precision oncology are distributed fairly within and between countries, avoiding exacerbating existing health disparities. Developing culturally appropriate methods for obtaining informed consent for genomic testing and data sharing is essential, especially in populations with varying levels of health literacy. Additionally, establishing robust data protection measures to safeguard patient information in the context of international data sharing is necessary, along with efforts to harmonize policies to ensure feasible and ethical implementation. These considerations are vital to ensure that the adoption of precision oncology in LMICs is effective, equitable, and respectful of diverse cultural contexts and individual rights.

Conclusion

Despite significant challenges, precision oncology presents a transformative opportunity for cancer care in LMICs. Success stories from various countries demonstrate that obstacles can be overcome through international collaborations, tailored solutions, and capacity-building. Key strategies include developing cost-effective diagnostics, strengthening infrastructure, improving education, and creating innovative drug access programs. Emerging technologies, global partnerships, and context-appropriate implementation strategies offer promising avenues for progress. Proteogenomics, in particular, provides valuable insights for diverse LMIC populations. Advancing precision oncology in LMICs requires sustained international collaboration, investment, and commitment to data sharing and equitable access. Collective action is essential to realize the potential of precision oncology globally, ensuring that all populations benefit from these advancements in cancer care.

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Digital transformation: Contributions from the São Paulo Regional Nursing Council

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Digital transformation in health has led to a revolution in professional practice, transforming patient care and health services. Technological innovations facilitate the incorporation of new tools and systems that optimize clinical processes, enable communication between health professionals and patients, and provide more effective health data management. This digital revolution stems from growing data processing capacity and global connectivity, which allow health systems and devices to be integrated into a cohesive and efficient network. Emerging technologies are being applied in various areas of healthcare practice, from diagnosis and treatment to clinical information management and remote patient monitoring (Coren-SP, 2024; Brazilian Ministry of Health, 2020).

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Digital transformation in health contributes to greater precision and speed in diagnosis and treatment, also reducing health errors and increasing therapeutic effectiveness. The computerization of health records in digital media and the integration of systems facilitate access to clinical information in real time, allowing health professionals to make informed and customized decisions. Technological innovations have increased access to health services, especially in remote and hard-to-reach areas. Telehealth services and other digital solutions have enabled remote care, reducing geographical barriers and democratizing access to quality health care (Coren-SP, 2024; Brazilian Ministry of Health, 2020).

In Brazil, the use of information and communication technologies (ICT) in health has been exponential and is supported by the country's Digital Health Strategy (Brazilian Ministry of Health, 2020). The Federal Council of Nursing (Cofen), in Resolution No. 696/2022, standardized the work of nursing professionals in digital health (Cofen, 2022). These initiatives have brought changes in work processes and the technological resources incorporated into the professional practice of nurses, nursing technicians, and auxiliar of nursing care.

To keep up with this trend in the country, Coren-SP set up CTED in 2022, whose primary purpose is to support the development of new policies, regulatory frameworks, and ethical guidelines to guide nursing practice in digital health in the state of São Paulo.

The scope of CTED's work is to ensure that nursing and digital health are integrated ethically, safely, and effectively into professional practice, contributing to the advancement of nursing in the current technological context and acting as a strategic body in the promotion and regulation of digital nursing. It is performed by nurses (PhDs, master's, and specialists) with knowledge and extensive experience working in the field of health informatics, as well as in teaching and research.

The actions carried out by CTED at Coren-SP include:

- Promoting debates and reflections on the work of professionals in the context of digital nursing in collaboration with representatives of Cofen, sector associations, specialist societies, and other organizations.
- Preparing guidelines to advise professionals in the state of São Paulo on the technical, scientific, ethical, and legal aspects of professional practice in digital health.
- Promoting reflections on the competencies of nursing professionals in digital health on topics such as telehealth, digital certification, training and development of nursing teams, and information system requirements.
- Developing materials that support good practices, such as the e-book *Enfermagem na saúde digital: aspectos essenciais para a prática segura e de qualidade* (Nursing in digital health: Essential aspects for safe and quality practice).[8]

[8] To find out more about the e-book, visit: https://portal.coren-sp.gov.br/wp-content/uploads/2024/09/Enfermagem-na-saude-digital.pdf

- Live broadcasting *Conversando com a Câmara Técnica* (Talking to the Technical Chamber) to discuss legislation and emerging issues in digital.

Considering the various realities of the profession that involve digital health in the state of São Paulo, one of the activities of Coren-SP's CTED is the construction of reasoned guidelines, opinions, and manifestos related to digital health within the scope of nursing practice, with a technical, scientific, ethical, and legal basis, as defined below.

- Reasoned guidelines: Documents formulated by CTED members, based on queries and requests for clarification regarding professional practice, as well as ethical and legislative issues pertaining to the category. The aim of these documents is both to address the doubts reported and to guide professional practice. The guidelines contained these documents apply only to the contexts described in the requests.
- Opinions: Experts' opinions on given subjects, with recommendations. Their precepts must be respected throughout the state of São Paulo.
- Manifestos: Technical matters relating to nursing practice, usually requested by the Public Prosecutor's Office or other government organizations and the Council's management (Coren-SP, 2024).

The CTED of Coren-SP is the first such body to be set up by the Cofen and Coren in the country, demonstrating its leading role in contributing to the ethical and legal aspects of nursing practice in digital health.

The CTED has been promoting debates and reflections on the role of nursing professionals in digital health on topics such as Cofen resolutions, telenursing, robotic surgery, certification of electronic record systems, AI, competencies in teaching nursing informatics, and digital tools in education, with representatives from Cofen and leaders in the field in the Americas and the Pan American Health Organization (PAHO). These reflections cover the digital competencies of nursing professionals, in conjunction with research groups and specialized societies, such as the SBIS, the Nursing Informatics Working Group, and related organizations, to encourage the development and adoption of these technologies in professional practice.

Objectives

This article proposes to present data on the skills in and use of ICT by nursing professionals in the practice of their profession in the state of São Paulo and to compare them with data from the ICT in Health survey, conducted in Brazil. It also proposes to present the reasoned guidelines, opinions, and manifestos related to digital health drawn up by the CTED within the scope of nursing practice since its establishment at Coren-SP.

Methods

A cross-sectional study was conducted to identify the skills in and use of ICT by nursing professionals in the exercise of their profession.

Nurses and nursing technicians and nursing auxiliar working in the state of São Paulo were invited to participate. The survey was publicized, and participants were invited via social media and e-mail, with a link to access the electronic questionnaire on Google Forms. Data was collected in November and December 2023 using a questionnaire designed by researchers. The research respected ethical aspects and was approved by the Research Ethics Committee (opinion 6.228.951) of the Botucatu School of Medicine at São Paulo State University (Unesp).

In the second section, the main themes of the reasoned guidelines, opinions, and manifestos related to digital health prepared by CTED/Coren-SP are also presented, based on the synthesis of the materials produced and the experience of CTED participants in this process.

Results

ICT SKILLS AND USE BY NURSING PROFESSIONALS

A total of 1,611 nursing professionals participated (48% nurses, 38% nursing technicians, and 14% nursing auxiliar), with a mean age of 42 years and 13 years working in the profession; the majority were female (84%), most were working in the city of São Paulo (48%), most were acting in practice (75%), and most were in a public institution (46%).

Participants declared their skill levels in using computers: basic (29%), intermediate (47%), and advanced (24%); mobile phones: basic (19%), intermediate (43%), and advanced (38%); and tablets: basic (27%), intermediate (44%), and advanced (28%). They reported using devices for work-related activities in the last month when the questionnaire was applied: computers (83%), mobile phones (63%), and tablets (14%). For work-related purposes, they used both their own and the institutions' devices (36%), only the institutions' (35%), only their own (22%), or did not use them at all (6%). These devices were used for the following purposes: recording patient data (74%), communication with teams (64%), communication with patients (27%), and telenursing activities (13%).

In summary, the nursing professionals reported having intermediate skills in the use of computers, mobile phones, and tablets. They used computers and mobile phones for work purposes, using their own and the institutions' devices to record patient data and communicate with teams. These findings give us an insight into the skills in and use of ICT by nursing professionals and how these technologies are used in work processes.

Since 2013, the ICT in Health survey has been investigating the adoption and use of ICT in Brazilian healthcare facilities, and presents how physicians and nurses use these tools in their work and the main barriers to their adoption. According to data from this survey, desktop computers have been the devices most available for use in healthcare facilities (81.9% in 2019 and 95.7% in 2022), followed by mobile phones (71% in 2019 and 72.5% in 2022) (Brazilian Internet Steering Committee [CGI.br], 2023). These figures are similar to those found in the investigation conducted by CTED.

In comparing the data reported by nursing professionals on their level of skill in using ICT with the historical evolution of the ICT in Health survey on nurses' participation in courses, training, or qualification in health informatics, it can be noted that the training item grew by 12% between 2019 and 2022. Specializations increased by 15% over the same period. However, it is important to highlight that there was no increase in master's and PhD degrees, whose percentages remained at 2% and 0%, respectively.

The ICT in Health 2022 survey also pointed out that nurses now have more access to patient data in electronic format, compared to the period before the pandemic. Information on immunizations administered to patients increased by 23% compared to 2019, information on vital signs increased from 63% to 77%, information in nursing notes increased from 66% to 81%, and information in the records of diagnoses, problems, or health conditions increased from 72% to 85%, corroborating the CTED's findings.

In addition, the results of the ICT in Health 2022 survey showed that nurses had more access to telehealth functionalities. This is mainly due to the need for teleconsultation and remote monitoring of patients as a result of the social distancing rules imposed by the COVID-19 pandemic and the regulation of the use of these resources to provide care.

Thus, it can be inferred that the results of the survey conducted by CTED with nursing professionals are congruent with the historical evolution of the ICT in Health survey in terms of nurses' familiarity with desktop computers and mobile phones, which are the tools most used to record and access patient data. Intermediate-level skills in using these tools are compatible with the training these professionals have received. The historical evolution of the ICT in Health surveys shows that nurses initially used these tools for more administrative purposes and gradually began to use them for clinical assessment activities, such as nursing diagnoses, nursing notes, and clinical parameter data.

REASONED GUIDELINES, OPINIONS, AND MANIFESTOS

The central themes of the reasoned guidelines, opinions, and manifestos prepared by CTED/Coren-SP between 2022 and 2024 are described below.

REASONED GUIDELINES

A total of 85 reasoned guidelines were produced during the period, which, for the purposes of this report, have been organized into 28 categories (identified by the authors) that indicate the main topics of interest and questions raised in the CTED debate:

- Remote patient monitoring;
- Telenursing activities;
- Technical responsibility;
- Sharing of information via WhatsApp;
- Electronic transcription of medical order;
- Publicizing offices on the Internet;
- Prescribing, requesting tests and medicines, and issuing prescriptions by teleconsultation;
- Dissemination of work schedules publicly and on social networks;

- Teleconsultation recording;
- Health monitoring via electronic platforms;
- Release of medical prescriptions issued and transmitted via WhatsApp;
- Drug prescriptions via telenursing;
- Telehealth in dressing care;
- Electronic patient records;
- Telephone and video assistance abroad;
- Professional registration for teleconsultation;
- Informed patient consent;
- Telenursing for diabetic patients;
- Telepropaedeutics devices;
- Brazilian General Data Protection Law (LGPD – Law No. 13.709/2018);
- Online nursing practice;
- Secure platforms for telenursing;
- Telenursing practice abroad;
- Digital signatures and certification;
- Hospital coding;
- Telehealth booths;
- Robotic surgery; and
- Dissemination of educational content on digital platforms.

OPINIONS

Five opinions were produced during the period, on the following topics:

- Robotic surgery;
- Follow-up of nursing professionals in medical teleconsultations;
- Informed patient consent;
- LGPD; and
- Hospital coding.

MANIFESTOS

Five manifestos were produced during the period, on the following topics:

- Remote monitoring;
- Remote monitoring and classification of cases in home isolation;
- Electronic signatures on patient records;
- Teleconsulting; and
- ICT-mediated nursing consultation.

The documents produced by CTED/Coren-SP guide the practice of nursing professionals in the state of São Paulo, contributing to the quality of care, patient safety, and the effectiveness of the actions developed. This strengthens the participation of nursing teams in the digital transformation of health as strategic agents.

The themes and categories identified in the materials produced (reasoned guidelines, opinions, and manifestos) are in line with the types of care provided for in the Professional Nursing Practice Law (Law No. 7.498/1986) and its regulating decree (Decree No. 94.406/1987), Cofen Resolution No. 564/2017 on the Code of Ethics for Nursing Professionals (Cofen, 2017), Cofen Resolution No. 696/2022 on the role of Nursing in Digital Health (Cofen, 2022), and Cofen Resolution No. 736/2024 on the implementation of the nursing process in socioenvironmental contexts where nursing care takes place (Cofen, 2024). These documents are also in line with the LGPD, the Brazilian Ministry of Health's Digital Health Strategy (Brazilian Ministry of Health, 2020), and PAHO's Digital Transformation Strategy (PAHO, 2021).

The central themes identified relate to patient care, registration, information security, and monitoring. The documents produced guide nursing professionals in the state of São Paulo with regard to the technical, scientific, ethical, and legal aspects of professional practice in digital health.

Final considerations

The research conducted by CTED and the Regional Center for Studies on the Development of the Information Society (Cetic.br) on the skills in and use of ICT by nursing professionals demonstrate the need to train these professionals in digital health, covering the different levels of training.

The establishment of the CTED by Coren-SP represents a milestone in the integration of nursing into the digital transformation in health, and the actions developed have a direct impact on nursing practice, promoting advances that influence the quality of care, patient safety, and effectiveness in the use of ICT.

The reasoned guidelines, opinions, and technical manifestos prepared by the CTED offer guiding parameters for nursing practice, ensuring that it is conducted ethically and safely. By aligning these practices with national regulatory frameworks, such as the LGPD, and the profession's ethical guidelines, CTED contributes to professionals being prepared to deal with the challenges of the digital transformation, promoting safe and qualified care.

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List of Abbreviations

AACR – American Association for Cancer Research

AI – Artificial Intelligence

ANPD – National Data Protection Authority

ANS – National Regulatory Agency for Private Health Insurance and Plans

C4 – Comprehensive Cancer Center in the Cloud

CATI – *computer-assisted telephone interviewing*

CBIS – Brazilian Congress of Health Informatics

CBO – Brazilian Occupational Classification

Cetic.br – Regional Center for Studies on the Development of the Information Society

CGI.br – Brazilian Internet Steering Committee

CHW – community health workers

CNES – National Registry of Healthcare Facilities

Cofen – Federal Council of Nursing

Coren-SP – São Paulo Regional Nursing Council

ctDNA – circulating tumor DNA

CTED – Digital Nursing Technical Chamber

Datasus – Departamento de Informática do Sistema Único de Saúde

DHR – Department of Health Research of the Government of India

DL – deep learning

EBSERH – Brazilian Company of Hospital Services

ECLAC – Economic Commission for Latin America and the Caribbean

Emram – Electronic Medical Record Adoption Model

ESD28 – Digital Health Strategy for Brazil 2020–2028

FISH – fluorescence in situ hybridization

HIBA – Hospital Italiano de Buenos Aires

HIC – high–income countries

HIMSS – Healthcare Information and Management Systems Society

IARC – International Agency for Research on Cancer

IBGE – Brazilian Institute of Geography and Statistics

ICGC – International Cancer Genome Consortium

ICPC – International Cancer Proteogenomic Consortium

ICT – information and communication technologies

IHC – immunohistochemistry

IoT – Internet of Things

IT – information technology

LGPD – Brazilian General Data Protection Law

LLM – large language models

LMIC – low- and middle-income countries

ML – machine learning

MS – Brazilian Ministry of Health

NGS – next generation sequencing

NIC.br – Brazilian Network Information Center

OECD – Organisation for Economic Co-operation and Development

PAHO – Pan American Health Organization

PHU – Primary Health Units

POND4Kids – Pediatric Oncology Networked Database

Proadi-SUS – Program for Institutional Development of the Brazilian Unified Health System

RNDS – National Health Data Network

SADT – diagnosis and therapy services

SBIS – Brazilian Society of Health Informatics

Seidigi – Digital Health and Information Secretariat

SUS – Unified Health System

TCGA – The Cancer Genome Atlas

UNESCO – United Nations Educational, Scientific and Cultural Organization

WHA – World Health Assembly

WHO – World Health Organization

XAI – Explainable Artificial Intelligence

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