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ICT in Health

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

2025

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Brazilian Network Information Center

ICT in Health

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

2025

Brazilian Internet Steering Committee
www.cgi.br

São Paulo
2026

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Publishing : Grappa Marketing Editorial (www.grappa.com.br)

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Dados Internacionais de Catalogação na Publicação (CIP)
(Câmara Brasileira do Livro, SP, Brasil)

Survey on the use of information and communication technologies in Brazilian healthcare facilities [livro eletrônico] : ICT in Health 2025 / [editor] Núcleo de Informação e Coordenação do Ponto BR. -- São Paulo : Comitê Gestor da Internet no Brasil, 2026.
PDF

Vários colaboradores
Bibliografia
ISBN 978-65-6165-017-5

1. Internet (Rede de computadores) - Brasil 2. Saúde - Brasil 3. Tecnologia da informação e da comunicação - Brasil - Pesquisa
I. Núcleo de Informação e Coordenação do Ponto BR.

26-348088.0 CDD-004.6072081

Índices para catálogo sistemático:
1. Brasil : Tecnologias da informação e da comunicação : Uso : Pesquisa 004.6072081
2. Pesquisa : Tecnologia da informação e comunicação : Uso : Brasil 004.6072081

Acknowledgments

The ICT in Health 2025 survey had the support of a notable network of experts, without which it would not be possible to deliver the results presented here. This group's contribution occurred through in-depth discussions about indicators, methodological design and also the definition of guidelines for data analysis.

The maintenance of this space for debate has been fundamental for identifying new areas of investigation, refining methodological procedures, and enabling the production of accurate and reliable data. It is worth emphasizing that the voluntary participation of these experts is motivated by the importance of new technologies for the Brazilian society and the relevance of the indicators produced by the Brazilian Internet Steering Committee (CGI.br) to be used in policymaking and academic research.

For the 12th edition of the ICT in Health survey, the Regional Center for Studies on the Development of the Information Society (Cetic.br) would like to specially thank the following experts:

Brazilian Association of Telemedicine and Telehealth (ABTMS)
Alexandra Monteiro and Suehellen Anne Rocha Milhomem

Brazilian Company of Hospital Services (EBSERH)
Gilliate Coelho

Brazilian Health Informatics Society (SBIS)
Antonio Carlos Onofre Lira and Luis Gustavo Kiatake

Brazilian Network Information Center (NIC.br)
Cristiane Millan

Digital Health and Information Secretariat of the Ministry of Health (Seidigi/MS)
Ana Estela Haddad

Federal University of Minas Gerais (UFMG)
Juliano Gaspar

Federal University of São Paulo (Unifesp)
Claudia Novoa and Ivan Torres Pisa

Getulio Vargas Foundation (FGV)
Ana Maria Malik

National Council of Health Secretaries (Conass)
Felipe Ferré and Nereu Henrique Mansano

National Council of Municipal Health Secretaries (Conasems)
Marizélia Leão Moreira

National Education and Research Network (RNP)
Paulo Roberto de Lima Lopes

National Regulatory Agency for Private Health Insurance and Plan (ANS)
Celina Oliveira

National School of Statistical Sciences (Ence)
Pedro Luis do Nascimento Silva

Oswaldo Cruz German Hospital (HAOC)
Wilma Madeira

Pontifical Catholic University of Paraná (PUCPR)
Cláudia Moro

São Paulo Regional Nursing Council (Coren–SP)
Heloisa Peres

School of Public Health of the University of São Paulo (FSP–USP)
Analluza Bolivar Dallari

Secretariat for Digital Transformation, Science and Technology of Pernambuco (SECTI-PE)
Rafael Diniz Toscano de Lima

Sergio Arouca National School of Public Health of the Oswaldo Cruz Foundation (ENSP–Fiocruz)
Marcelo Fornazin and Mariana Albuquerque

Telemedicine University Network (Rute)
Luiz Ary Messina

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Foreword

The Internet is a network built over decades through collective effort. It has established itself as an essential infrastructure for contemporary society, enabling economic activities, public policies, fundamental services, and various forms of social interaction. More than just offering a set of applications and services visible to end users, the Internet operates on an open, neutral, interoperable, and distributed technical architecture, whose integrity is a prerequisite for innovation, inclusion, and the exercise of rights in the digital environment.

Following the guiding principles of the Internet and in constant interaction with the Brazilian Internet Steering Committee (CGI.br), the Brazilian Network Information Center (NIC.br) plays its role in coordinating and strengthening the Internet in Brazil. In 2025, 20 years after its reconfiguration as a legal entity, NIC.br reaffirmed its commitment to managing critical network resources, operating stable infrastructure, and promoting a secure, accessible, and high-quality digital environment for Brazilians. This institutional milestone occurred in an equally significant context, alongside the celebration of the 30th anniversary of CGI.br—internationally recognized as a successful experiment in multistakeholder Internet governance.

One of NIC.br's various areas of activity focused on digital security is the Brazilian National Computer Emergency Response Team (CERT.br), which has played a central role in coordinating incident responses, disseminating best practices, and strengthening technical capabilities for online security, contributing to the resilience of the country's Internet infrastructure. These actions are linked to the publication of extensive awareness-raising and training material, always reinforcing the importance of a preventive and collaborative approach to security in the digital environment.[1]

Promoting a more accessible and inclusive Internet is also part of NIC.br's agenda. The Web Technologies Study Center (Ceweb.br) plays a role in this area, developing initiatives focused on digital accessibility and the standardization of web technologies.[2]

[1] More information about these actions can be found at https://internetsegura.br/

[2] Among the initiatives related to technical standards, Ceweb.br|NIC.br was part of the committee that drafted the ABNT NBR 17225 standard, focused on accessibility requirements for web content and applications. More information at https://ceweb.br/projetos/norma-abnt/

In a more technical field, the Center of Study and Research in Network Technology and Operations (Ceptro.br) works to continuously improve Brazil's Internet infrastructure through initiatives to measure connection quality, disseminate best practices for network protocols, train professionals, and provide services essential to Internet operations.[3] It was also through the actions of Ceptro.br|NIC.br that the Brazil Internet Exchange (IX.br)[4] originated and operates. It currently reaches more than 40 Tbit/s of aggregate traffic in the 38 locations where it is present, being the largest set of Internet exchange points (IXPs) in the world, with approximately 3,900 participating Autonomous Systems (AS). It should be noted that the São Paulo point is currently the world's leading IXP.

Adding to NIC.br's efforts is the creation of the Brazilian Artificial Intelligence Observatory (OBIA). It provides data and indicators that broaden understanding of the impacts and challenges of Artificial Intelligence (AI) in the country, supporting public debate and the formulation of policies aimed at its responsible use.[5]

Throughout its activities, NIC.br maintains and supports initiatives to promote the Internet and its safe, responsible, and conscious use. Annual events such as Safe Internet Day,[6] the Seminar on Privacy and Personal Data Protection,[7] and the Symposium on Children and Youth on the Internet[8] represent the ongoing effort to coordinate technical, legal, and social debates on key issues on the digital agenda. These actions highlight the importance of protecting personal data, ensuring information integrity, and safeguarding rights in the digital environment, especially for children.

In this context, the Regional Center for Studies on the Development of the Information Society (Cetic.br) is the NIC.br department responsible for regularly producing indicators and analyses on access, use, and appropriation of information and communication technologies (ICT) in Brazil. Cetic.br|NIC.br has established itself as a national and international reference in the production of reliable, comparable data aligned with internationally recognized methodological standards, which support the formulation of public policies, academic research, and multisectoral debate on the development of digital technologies.

In 2025, Cetic.br|NIC.br expanded its participation in international forums and agendas, contributing empirical evidence and methodological expertise to debates within the scope of BRICS and the Southern Common Market (Mercosur) meetings,[9] as well as other multilateral spaces. In these instances, topics such as meaningful connectivity, AI adoption, and reducing inequalities in access to and use of digital technologies took center stage, underscoring the importance of comparable, context-specific indicators to guide both regional and international cooperation.

[3] The main projects and initiatives of Ceptro.br|NIC.br can be accessed at https://ceptro.br/#projetos

[4] More information at https://ix.br/

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

[6] More information at https://www.diadainternetsegura.org.br/

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

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

[9] Publications with BRICS and Mercosur, among other international organizations, can be accessed at https://cetic.br/en/publicacoes/indice/outros/

This year, Cetic.br|NIC.br began new studies focused on strategic topics for the development of the Brazilian digital ecosystem, such as the analysis of data center infrastructure, which is now essential for data processing, storage, and sharing, as well as for the expansion of applications based on cloud computing and AI. Another strategic topic concerns information integrity, which is central to analyzing information flows and trust in data sources, as well as to addressing challenges associated with misinformation in the digital environment.

By swiftly addressing emerging and relevant topics such as connectivity quality, digital competencies, privacy, AI use, critical infrastructure, and security, Cetic.br|NIC.br's surveys help understand the multiple factors that enable effective, meaningful connectivity. Measuring access remains essential, but it is increasingly necessary to understand the conditions of use, associated risks, and capabilities required for individuals and organizations to fully benefit from digital technologies.

The financial resources generated by .br domain registrations, managed by Registro.br|NIC.br, enable continuous investment in research, security, training, and technological development, sustaining a virtuous cycle that benefits the Internet in Brazil. In a scenario of rapid technological change and growing dependence on digital infrastructure, the governance model adopted by the country since 1995 remains current and fundamental, supporting an open, secure Internet guided by the public interest.

The purpose of this publication is to contribute to the quality of public debate and strengthen the formulation, monitoring, and evaluation of evidence-based public policies. By gathering reliable data and consistent analyses, NIC.br and CGI.br reaffirm their commitment to multistakeholder governance, the promotion of rights, the reduction of inequalities, and the construction of a more inclusive, accessible, and secure digital environment, capable of responding to contemporary challenges and expanding opportunities for Brazilian society.

Enjoy your reading!

Demi Getschko
Brazilian Network Information Center – NIC.br

Presentation

The intensification of digital transformation has significantly expanded the role of the Internet as an essential infrastructure for exercising rights and accessing information, education, social participation, and knowledge production. The Internet is also a strategic tool for formulating, implementing, and evaluating public policies aimed at innovation and economic and social development. In a context of rapid technological change, the expansion of digital platforms, and the growing use of automated data-based systems, there are increasing challenges associated with organizing the digital ecosystem. Ensuring that this ecosystem reduces inequalities, protects rights, and serves the public interest and national sovereignty is an urgent task that requires participatory institutional arrangements capable of guaranteeing democratic governance.

It is in this context that the Brazilian Internet Steering Committee (CGI.br) operates. In 2025, it celebrated 30 years of defending an open, secure, and inclusive Internet. The Brazilian multistakeholder model of Internet governance has established itself as a legitimate space for dialogue and collective construction, bringing together the government, the private sector, civil society organizations, and technical and academic communities in the formulation of principles, recommendations, and guidelines that steer the development of the Internet in the country. This approach becomes even more relevant in light of the growing complexity of challenges associated with the digital environment, such as personal data protection, transparency and accountability of digital platforms, tackling disinformation, and the impact of the use of automated systems and Artificial Intelligence (AI) on fundamental rights.

Throughout 2025, CGI.br actively participated in key debates on the future of Internet governance in Brazil and around the world, with an emphasis on discussions and public consultations[1] related to the regulation of digital platforms and the protection of rights in the online environment. The Committee contributed to the formulation of principles and recommendations aimed at balancing technological innovation, the protection of freedom of expression, and the need to safeguard users, particularly groups in situations of greater vulnerability, such as children.

[1] One of the results of this debate was the publication, in 2025, of the *Princípios do CGI.br para Regulação de Plataformas de Redes Sociais* (CGI.br Principles for the Regulation of Social Networks), available in Portuguese at https://cgi.br/pagina/principios-cgibr-regulacao-redes-sociais/

The contributions of CGI.br to the debate on the Brazilian Digital Statute of the Child and Adolescent (ECA Digital),[2] enacted in 2025, were based on the understanding that the comprehensive protection of children in the digital environment must be accompanied by measures that preserve the open architecture of the Internet and avoid solutions that compromise fundamental rights. The recommendations on age verification, the responsibility of application providers, and the promotion of safer digital environments reflect the pursuit of proportionate, evidence-based solutions aligned with the principles of multistakeholder Internet governance.[3]

Within the scope of this activity, the 15th edition of the Brazilian Internet Governance Forum (FIB, as per its acronym in Portuguese) in 2025 reinforced CGI.br's role as a facilitator of plural and qualified debates on the digital environment. The FIB brought together representatives from different sectors to discuss topics such as platform regulation, information integrity, digital sustainability, and meaningful connectivity. More than just a space for debate, the event has established itself as an environment for listening, building consensus, and formulating proposals aligned with both the national context and international Internet governance agendas.

The work of CGI.br is inseparable from the production of quality data and empirical evidence that inform public debate and decision-making. The Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of the Brazilian Network Information Center (NIC.br), plays a strategic role in providing fundamental data for the formulation, monitoring, and evaluation of public policies related to digital technologies. In 2025, upon completing 20 years of operation, Cetic.br|NIC.br reaffirmed its ability to respond quickly and competently to debates on the digital environment, systematically incorporating new topics and indicators into its research agenda.

An example of this responsiveness is the production of indicators and analyses widely used to monitor the implementation of public policies and regulatory frameworks, such as ECA Digital and Law No. 15.100/2025,[4] which provides for the use of personal devices by students in basic education facilities. Regular surveys by Cetic.br|NIC.br, such as ICT Kids Online Brazil and ICT in Education, produce data on the use of digital technologies by children and families, school mediation practices, and exposure to risks in the online environment. This data contributes to a deeper understanding of the challenges these young people face and is essential for evaluating the effectiveness of adopted policies and regulations, as well as guiding adjustments that protect rights without compromising access to or the positive use of digital technologies.

[2] Available at https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2025/lei/L15211.htm

[3] CGI.br's recommendations regarding the ECA Digital can be found at https://cgi.br/media/docs/publicacoes/4/pt/20251118175422/CGIbr_Contribuicoes_Consulta_MJ_Afericao_Idade.pdf and https://cgi.br/media/docs/publicacoes/4/pt-br/20251215152052/Contribuicoes_CGIbr_Tomada_Subsidios_ANPD_ECA_Digital.pdf

[4] Available at https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2025/lei/l15100.htm

By disseminating indicators and studies on meaningful connectivity, digital competencies, responsible use of technologies, information integrity, and protection of rights, among other topics, Cetic.br|NIC.br helps to provide a more comprehensive understanding of the effects of digital transformation on Brazilian society and to strengthen evidence-based public policies.

At the international level, in coordination with CGI.br and in cooperation with ministries, Cetic.br|NIC.br maintained active participation in multilateral and regional forums, such as the BRICS and the Southern Common Market (Mercosur) agendas, contributing to debates on digital governance, connectivity, inclusion, and sustainability. This action reinforces the importance of international collaboration and the production of comparable indicators to address common challenges, while respecting national and regional specificities. In the same vein, it is worth highlighting Brazil's commitment to multisectoral governance, evidenced by CGI.br's participation in the WSIS+20 renewal process.

In 2025, a sectoral study on data centers in Brazil was launched and conducted by Cetic.br|NIC.br with the support of a multisectoral group of experts and government agencies, including the Ministry of Science, Technology, and Innovation (MCTI), the Ministry of Development, Industry, Trade, and Services (MDIC), and the Ministry of Finance (MF). The study seeks to fill information gaps in a context where these infrastructures play an increasingly strategic role in the digital economy, development policies, technological sovereignty, and environmental challenges.[5]

Therefore, in a global environment marked by growing tensions, rapid technological advances, and disputes over regulatory models, CGI.br reaffirms the centrality of multistakeholder governance to strengthen a secure, open, and public-interest-oriented Internet. This publication showcases the efforts to gather reliable, robust public data produced within the scope of Cetic.br|NIC.br, which supports democratic debate, the formulation of public policies, and the construction of a more just, inclusive, and human-development-oriented digital environment.

Renata Vicentini Mielli
Brazilian Internet Steering Committee – CGI.br

[5] The initial results of this study can be accessed at https://cetic.br/en/publicacao/ano-xvii-n-4-data-centers-no-brasil/

Executive Summary

ICT IN HEALTH
SURVEY 2025

Executive Summary ICT in Health 2025

The ICT in Health survey, conducted since 2013, investigates the adoption and use of information and communication technologies (ICT) in Brazilian healthcare facilities, allowing for the monitoring of the evolution of digital health in the country. In this edition, the results highlight the consolidation of digital infrastructure in health services, with the universalization of access to computers and the Internet, as well as advances in the provision of digital services to patients and the adoption of emerging technologies, such as Artificial Intelligence (AI). At the same time, challenges related to the interoperability of information systems, data security, and institutional capacity building persist, highlighting inequalities between types of facilities and administrative jurisdictions.

The "Analysis of Results" section of the survey presents more details about the results of this edition.

ICT Infrastructure

In 2025, access to computers and the Internet remained virtually universal in Brazilian healthcare facilities, reaching 99% of units, with no differences between the public and private sectors. Desktop computers are still the primary device (97%), followed by laptops (71%) and tablets (41%).

Significant differences can be observed in the usage profile of these devices. The use of laptops was more frequent in private facilities (83%) and in inpatient facilities with more than 50 beds (91%). Tablets were more prevalent in public facilities (53%) and in Primary Health Units (PHU) (63%), possibly associated with the activities of primary care teams.

The universalization of connectivity reinforces its role as a structuring element for the functioning of health services, enabling the use of electronic systems, communication between professionals, and the provision of digital services.

97% OF PHU USE AN ELECTRONIC SYSTEM TO RECORD PATIENT INFORMATION

Electronic health records and information exchange

The use of electronic systems to record patient information remained stable in 2025 (92% of healthcare facilities). Small improvements were observed in inpatient facilities with up to 50 beds (from 78% to 81% between 2024 and 2025) and in diagnosis and therapy services (SADT) (from 94% to 96%), indicating the continuity of the sector's computerization process.

This progress is reflected in the greater availability of patient data in electronic format, such as information related to patient demographics (92%), detailed clinical notes from encounters with clinicians or medical history (82%), and patient's diagnoses, health problems, or conditions (79%), which are available in this format in most healthcare facilities.

Despite this, the ability to exchange information between facilities is still limited. By 2025, 44% of units had systems that allowed for the sending or receiving of electronic referrals, with a higher incidence in the public sector (64%) compared to the private sector (28%). This trend is repeated in other types of clinical information exchange, such as discharge reports and clinical data, demonstrating greater integration in public healthcare networks (Chart 1).

This edition features a new indicator that investigates the integration of healthcare facilities into the National Health Data Network (RNDS). The results indicate that 44% of them were integrated, more commonly in PHU (72%), in the public sector (64%), and in the North (53%) and Northeast (50%) regions (Chart 2). These results indicate progress in the implementation of national interoperability policies, although the fragmentation of systems still represents a significant challenge for care coordination.

Digital services for patients and telehealth

There has been a growing trend in the provision of certain digital services to patients in recent years. In 2025, viewing lab test results was offered by 39% of facilities, followed by booking appointments (34%) and booking lab tests (32%). The most significant increase occurred in online interactions with the healthcare team, which rose from 16% in 2023 to 35% in 2025, indicating greater use of digital communication channels.

The availability of these services varies depending on the type of facility. SADT showed greater availability of viewing lab test results (72%), while PHU stood out in interaction with health teams (42%) and viewing electronic medical records (25%), reflecting the specifics of the care provided.

The adoption of telehealth services also progressed. Teleconsulting was the most widespread service, present in 36% of facilities, followed by teleconsultation (28%), telediagnosis (27%), and telemonitoring (20%). These results indicate an expansion in the use of these technologies, with the potential to strengthen care coordination and expand access to health services.

Adoption of emerging technologies

The 2025 edition of ICT in Health introduced a methodological shift by expanding the investigation into the use of Big Data and AI to all facilities with computers, not just those with an information technology (IT) department, reflecting greater accessibility of these technologies and their use through external services.

BOX 1

–

INFORMATION SECURITY AND DATA PROTECTION

The adoption of information security practices remains limited in healthcare facilities. In 2025, 42% of units had an information security policy, with significant differences between the public sector (28%) and the private sector (54%). Inpatient facilities with more than 50 beds (72%) and SADT (64%) showed higher levels of adoption of these policies. Furthermore, around half of the facilities (47%) conducted information security training for their employees, a crucial measure to mitigate risks associated with the improper use of systems and the exposure of sensitive data.

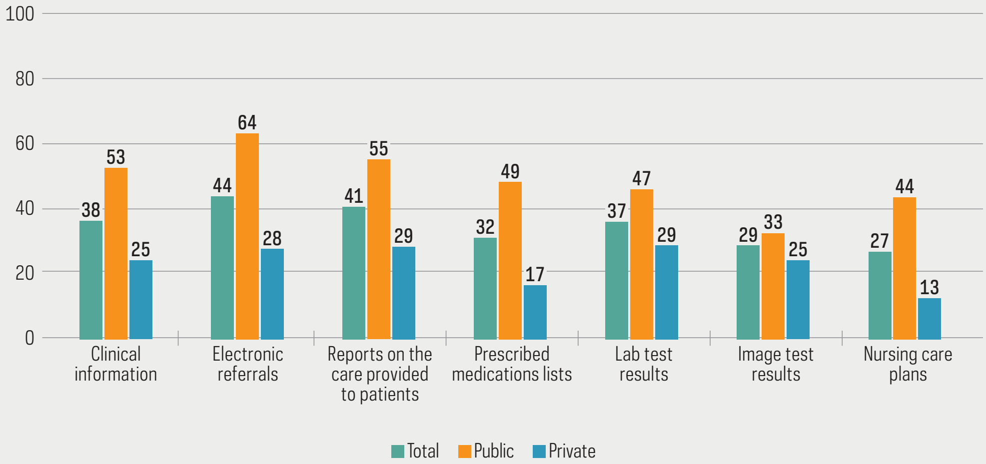
Regarding compliance with the Brazilian General Data Protection Law (LGPD), the results indicate that less than half of the facilities implemented the actions investigated by the survey. The most common practice was conducting internal awareness campaigns (46%), while more robust measures, such as appointing a Data Protection Officer (30%) and implementing response plans (30%), remain restricted to a smaller percentage of facilities. These results highlight challenges in consolidating data governance in the context of digital health.

CHART 1

—

Healthcare facilities by available electronic healthcare information exchange functionalities (2025)

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



28% of facilities offer teleconsultation

27% of facilities offer telediagnosis services

20% of facilities offer telemonitoring

CHART 2

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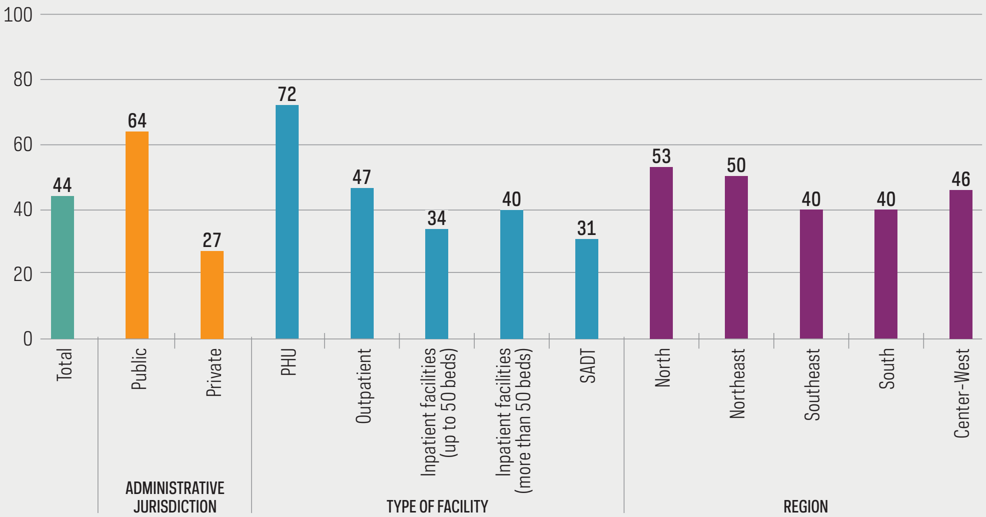
Healthcare facilities by integration to the RNDS (2025)

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



The results indicate that 9% of facilities conducted Big Data analytics, with a higher incidence in the private sector (11%) and among inpatient facilities with more than 50 beds (30%). The use of this technology is strongly associated with the analysis of data generated internally by the facilities, such as medical records and administrative files, as well as information from smart devices.

Cloud services, such as email (63%) and file storage or databases (57%), were present in more than half of healthcare facilities, while office software (32%) and processing capacity (38%) were the least used or available cloud tools.

15% OF INPATIENT FACILITIES WITH MORE THAN 50 BEDS USED IoT

Other emerging technologies investigated by the survey were used by a smaller percentage of facilities: 9% used the Internet of Things (IoT), and 5% used robotics.

ARTIFICIAL INTELLIGENCE

AI was used by 18% of healthcare facilities, more frequently in inpatient facilities with more than 50 beds (31%) and in SADT (29%), indicating a greater concentration of these technologies in contexts with greater technical and organizational capacity.

Among the facilities that use AI, generative language models stand out, present in 76% of them, followed by text mining tools (52%) and workflow automation (48%) (Chart 3). These technologies are mainly used for organizing clinical and administrative processes (45%), improving digital security (36%), and treatment efficiency (32%) (Chart 4).

Despite progress, significant barriers to adoption remain. Among inpatient facilities with more than 50 beds, the following stand out: high costs (63%), not being a priority (56%), and limitations related to data availability and professional training (51%). In SADT, factors such as lack of interest (60%), concerns regarding privacy (50%), and high costs (47%) also appear as significant obstacles.

The results of the ICT in Health 2025 survey indicate the consolidation of digital infrastructure in healthcare facilities, advances in the provision of digital services, and the adoption of emerging technologies. However, challenges related to interoperability, data governance, and reducing inequalities between different types of facilities persist. In this context, strengthening public policies and investments in training, infrastructure, and systems integration will be fundamental to ensuring that digital transformation contributes to a more efficient, equitable, and population-centered healthcare system.

Survey methodology and access to data

The twelfth edition of the ICT in Health survey collected data about healthcare facilities. Data was collected using telephone interviews and a web questionnaire with 3,270 managers between February and November 2025. 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)—https://www.cetic.br/en/. The methodological and data collection reports are available in both book format and on the website.

CHART 3

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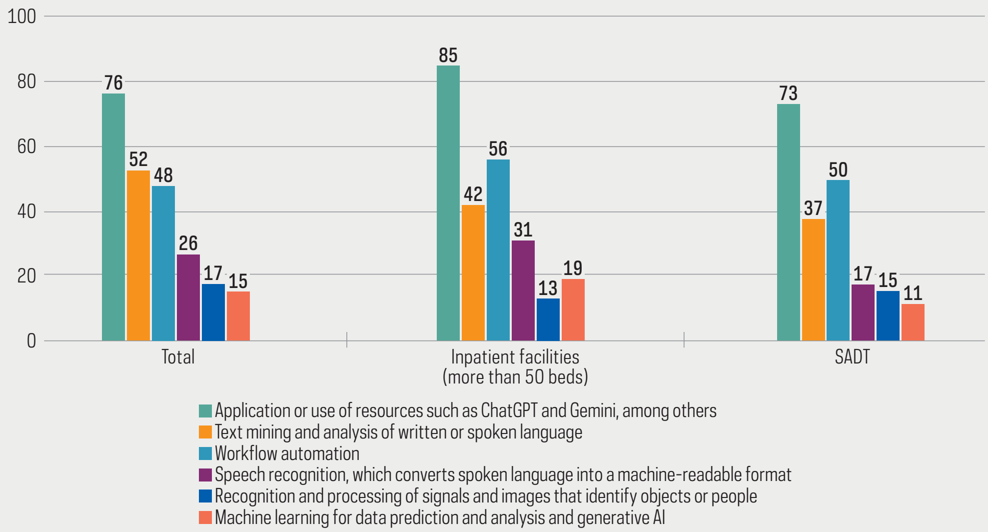
Healthcare facilities that used AI technologies, by type of tool (2025)

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



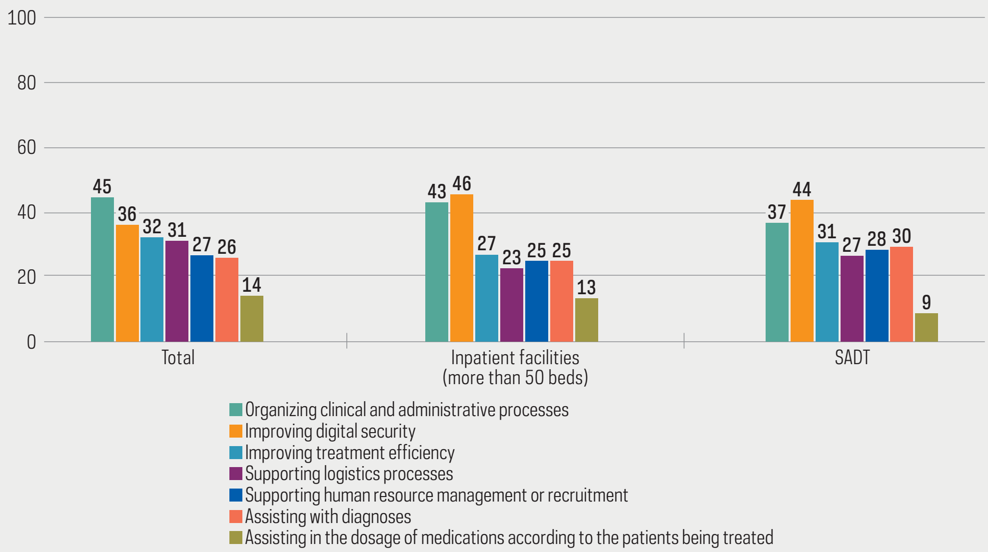
18%	31%	29%
of healthcare facilities used AI	of inpatient facilities with more than 50 beds used AI	of SADT used AI

CHART 4

—

Healthcare facilities that used AI technologies, by type of application (2025)

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



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

PERCENTAGE (%)		YES	NO	DOES NOT KNOW	DID NOT ANSWER	DOES NOT APPLY
TOTAL		92	7	0	0	1
ADMINISTRATIVE JURISDICTION	Public	91	8	0	0	1
	Private	93	6	0	0	1
REGION	North	85	14	0	0	0
	Northeast	90	8	0	0	1
	Southeast	93	5	0	0	1
	South	95	5	0	0	0
	Center-West	94	6	0	0	0
TYPE OF FACILITY	Outpatient	92	7	0	0	1
	Inpatient (up to 50 beds)	81	18	0	0	1
	Inpatient (more than 50 beds)	94	5	0	0	0
	Diagnosis and therapy services	96	3	1	0	0

Indicator responses

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. (2026). *Survey on the use of information and communication technologies in Brazilian healthcare facilities: ICT in Health 2025* [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
2025

Methodological Report
ICT in Health 2025

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 the 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)

Since 2021, the survey sample has been reformulated to facilitate the production of estimates disaggregated by federative units. To enable the generation of this information, the survey sample included a larger number of facilities in the first year, whereas in the second year, it included a smaller sample with information on facilities and health professionals. The aim is to have estimates by federative unit in the first year, based only on the expanded sample of facilities. In the second year, updated estimates of facilities in the states are published for the two-year period, aggregating information from two consecutive years. Estimates of indicators for health professionals will still only be presented for the geographical cut-off of large regions.

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 the IBGE Survey of Medical-Sanitary Assistance. 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;
- diagnosis and therapy services (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 were considered to be analysis units. In 2025, no data was collected from physicians and nurses (healthcare professionals).

DOMAINS OF INTEREST FOR ANALYSIS AND DISSEMINATION

- **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 non-capital 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.

Data collection instruments

INFORMATION ON THE DATA COLLECTION INSTRUMENTS

The information of interest to this edition of the survey was collected through a structured questionnaire with closed and open questions (when necessary), which was administered to administrative professionals in the facilities (preferably information technology [IT] managers). For more information about the questionnaire, 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 Brazilian Ministry of Health. Established by Ordinance MS/SAS No. 376, of October 3, 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 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

Most of the parameters of interest that the survey sought to estimate were proportions and counts by domains. 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 total sample size for the ICT in Health survey is approximately 7,100 facilities every two years. 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. 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 using the *ipf* function of the human league 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".

SAMPLE SELECTION

HEALTHCARE FACILITIES

Within each stratum, healthcare facilities were selected using simple random sampling. Thus, the sample size within each stratum is given 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

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

π_{ih} is the inclusion probability of healthcare facility i in stratum h

n_h is the sample size within each stratum h

N_h is the population size in stratum 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 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.

Managers who opted for this modality were sent a link specifically 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

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 cases in which facilities did not respond, the non-response rate and the number of responding facilities in each of the strata planned in the survey are evaluated. When the vast majority of strata have at least one responding facility, a simple nonresponse correction per stratum is made. This correction is given by Formula 4.

FORMULA 4

$$w^*_{ih} = w_{ih} \times \frac{\Sigma_i^{n_h} w_{ih}}{\Sigma_1^{n_h} w_{ih} \times I^r_{ih}}$$

w^*_{ih} is the adjusted weight for nonresponse by facility i in stratum h

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

I^r_{ih} is an indicator variable that is given a value of 1 if facility i in stratum h responded to the survey and 0 otherwise

n_h is the total sample of facilities in stratum h

In cases where many strata do not have respondents, the correction for nonresponse is made using a logistic model to predict the probability of response. The model uses variables from the CNES registry to estimate the likelihood of responding to the survey (details of the model, when used, can be found in the "Data Collection Report"). The result of the model is the estimated response probability for each of the facilities participating in the survey. Nonresponse is then corrected using Formula 5.

FORMULA 5

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

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

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

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

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^{*C}_{ih}

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
2025

Data Collection Report
ICT in Health 2025

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 2025 ICT in Health survey. The objective of this report is to provide information about specific characteristics of the 2025 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

The allocation of the sample of healthcare facilities is presented in Table 1.

TABLE 1

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

		Planned sample
Administrative jurisdiction	Public	7 195
	Private	8 555
Type of facility	Outpatient	10 865
	Inpatient (up to 50 beds)	1 421
	Inpatient (more than 50 beds)	1 028
	Diagnosis and therapy services	2 436

CONTINUES ►

▶ CONCLUSION

		Planned sample
Federative unit	Rondônia	287
	Acre	184
	Amazonas	425
	Roraima	181
	Pará	496
	Amapá	141
	Tocantins	352
	Maranhão	820
	Piauí	473
	Ceará	532
	Rio Grande do Norte	435
	Paraíba	599
	Pernambuco	911
	Alagoas	754
	Sergipe	481
	Bahia	932
	Minas Gerais	980
	Espírito Santo	547
	Rio de Janeiro	868
	São Paulo	1 258
	Paraná	688
	Santa Catarina	629
	Rio Grande do Sul	672
	Mato Grosso do Sul	348
	Mato Grosso	592
	Goiás	561
	Federal District	604

Data collection instruments

INFORMATION ON THE DATA COLLECTION INSTRUMENTS

The data was collected through a structured questionnaire applied to administrative professionals in the facilities (preferably information technology [IT] managers). Thus, information on the healthcare facilities was obtained from professionals at the managerial level, 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.

CHANGES IN THE DATA COLLECTION INSTRUMENTS

Based on the results of the pre-test interviews, changes were made to the survey questionnaires. The goal was to align them with the standards currently under discussion in international forums for collecting data on ICT use in the health sector.

Other modifications were made to test new items relevant to understanding the context of ICT access and use in the sector, as well as to improve data collection.

The main changes to the questionnaire on healthcare facilities include the following:

Module A – Profile of the facility/respondent:

- The item that investigated whether the respondent had completed a master's or doctoral degree was split into two separate items.
- "Dialysis" was added to the item that investigates what types of complementary treatments are offered by healthcare facilities.
- Exclusion of indicators that collected data on the number of physicians and nurses working in the departments of healthcare facilities.

Module B – ICT infrastructure at the facility:

- Update on the download speed tiers contracted by healthcare facilities.

Module C – Electronic health records and information exchange

- Addition of an indicator that collects information on whether healthcare facilities are integrated into the National Health Data Network (RNDS) of the Brazilian Ministry of Health.

Module H – New technologies:

- Change in the scope of the questionnaire, which previously applied only to healthcare facilities with IT areas or departments, and now applies to healthcare facilities with computers.
- Addition of an example for the item that investigates whether healthcare facilities have used the Internet of Things (IoT).
- Inclusion of generative Artificial Intelligence (AI) among the types of AI tools used by healthcare facilities.
- Inclusion of a new item regarding ethical and/or legal regulatory issues in the question that measures the non-use of AI by healthcare facilities.

PRETESTS

Six interviews were conducted with general or IT managers of healthcare facilities between February 12 and 14, 2025, 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 2025 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 was performed by 82 interviewers, one supervisor and two assistants.

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 2025 ICT in Health survey, preference was given to IT managers, who answered questions about the healthcare facilities.

Healthcare facility managers were contacted using the computer-assisted telephone interviewing (CATI) technique. The questionnaire administered via CATI was also made available for self-completion online to all managers and healthcare professionals who requested it. The interviews to administer the questionnaires lasted approximately 37 minutes via CATI.

DATA COLLECTION PERIOD

Data for the 2025 ICT in Health survey was collected from the sampled healthcare facilities between February and November 2025. 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

–

Number of recorded cases, according to field situations

Situations		Total
Block 1	Could not speak with a representative of the healthcare facility	8 093
Block 2	Spoke with a representative of the healthcare facility or the respondent, but did not complete the interview	1 785
Block 3	Interview with the healthcare facility manager fully completed	3 270
Block 4	Definite impossibility of carrying out interview with the healthcare facility manager	1 011
Block 5	Follow up to the web questionnaire	0

DATA COLLECTION RESULTS

In the 2025 ICT Health survey, 3,270 healthcare facilities were interviewed, which represents 21% of the planned sample of 15,750 facilities. 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	21%
	Private	21%
Type of facility	Outpatient	19%
	Inpatient (up to 50 beds)	27%
	Inpatient (more than 50 beds)	36%
	Diagnosis and therapy services	18%

CONTINUES ▶

▸ CONCLUSION

		Response rate
Federative unit	Rondônia	18%
	Acre	11%
	Amazonas	12%
	Roraima	11%
	Pará	11%
	Amapá	18%
	Tocantins	18%
	Maranhão	5%
	Piauí	12%
	Ceará	12%
	Rio Grande do Norte	15%
	Paraíba	16%
	Pernambuco	19%
	Alagoas	13%
	Sergipe	20%
	Bahia	14%
	Minas Gerais	30%
	Espírito Santo	24%
	Rio de Janeiro	14%
	São Paulo	36%
	Paraná	39%
	Santa Catarina	36%
	Rio Grande do Sul	36%
	Mato Grosso do Sul	22%
	Mato Grosso	18%
	Goiás	20%
	Federal District	23%

Analysis of Results

ICT IN HEALTH SURVEY
2025

Analysis of Results
ICT in Health 2025

The digital transformation of the healthcare sector has been seen as a central strategy to address the challenges faced by healthcare systems worldwide. Among these challenges, we can also highlight inequalities in access, fragmentation of services and records, and difficulties in coordinating care and care pathways for each citizen/patient. Technologies such as electronic health records, telehealth, mobile applications, and data analysis methods can contribute to making health systems more efficient, accessible, and patient-centered (Garcia Saisó et al., 2022; Silva Jr. et al., 2025).

The incorporation of these tools enables advancements in the management of clinical information, integration between different levels of healthcare, and expansion of the provision of digital services to patients. At the same time, digital transformation involves organizational changes, development of digital skills, strengthening of health information systems, and greater availability of professionals. When implemented in a secure, integrated, interoperable, and equity-oriented manner, digital solutions can improve access to services, enhance continuity of care, and enhance the resilience of health systems (World Health Organization [WHO] & Pan American Health Organization [PAHO], 2023).

The Brazilian Ministry of Health has been structuring a digital transformation agenda for the Unified Health System (SUS) through initiatives that combine technological innovation, connectivity, and the strategic use of data. The creation of the Digital Health and Information Secretariat (Seidigi) consolidated this process by centralizing the coordination of digital health policies, promoting the incorporation of solutions such as electronic health records, telehealth, and integrated information systems, with the aim of expanding access, ensuring continuity of care, and strengthening the management of the system. In this context, the National Health Data Network (RNDS) constitutes the main interoperability infrastructure of SUS, allowing the secure and standardized sharing of information between different health facilities and levels of care. This integration enables the construction of a unified clinical history and supports clinical and managerial decision-making. Additionally, the program Meu SUS Digital (My Digital SUS) expands public access to health information and digital services, contributing to greater transparency, continuity of care, and user participation in the health system.

In addition, more recent policies have sought to expand the population's access to specialized care and strengthen the organization of the network through the use of digital technologies. The Agora Tem Especialistas (Now We Have Specialists) program incorporates a digital component that integrates data, services, and platforms such as SUS Digital and RNDS, enabling the monitoring of the patient journey, waiting line management, and the expansion of service offerings through telehealth (Brazilian Ministry of Health, 2025).

In this context, understanding the level of digitalization of healthcare facilities and the use of digital technologies in their services becomes fundamental to monitoring the advancement of digital transformation in the sector and identifying challenges to its consolidation in the country.

In its 12th edition (2025), the ICT in Health survey presents indicators on information and communication technology (ICT) infrastructure, information technology (IT) management, the use of electronic systems, the provision of online services to patients, and the adoption of emerging technologies in Brazilian healthcare facilities. In this edition, the survey presents new indicators on adherence to the RNDS by healthcare facilities, and makes changes to the indicators related to emerging technologies such as Artificial Intelligence (AI) and Big Data.

In this edition, the analysis of the results is structured in the following sections:

- ICT infrastructure in healthcare facilities;
- Electronic health records and information exchange;
- Governance and information security;
- Online presence, digital services for patients, and telehealth;
- Adoption of emerging technologies in healthcare facilities;
- Final considerations: Agenda for public policies.

ICT infrastructure in healthcare facilities

The availability of ICT infrastructure is one of the cornerstones of the advancement of digital health. The presence of adequate equipment, quality connectivity, and information systems capable of supporting data recording and sharing is a fundamental condition for the implementation of digital solutions in healthcare services.

This infrastructure enables the adoption of tools such as electronic health records, telemonitoring, and teleconsultations, in addition to facilitating the exchange of information between facilities and supporting the work of healthcare professionals. In this context, a robust technological base contributes not only to expanding the supply of digital services to the population, but also to improving management efficiency and strengthening care coordination across different levels of care (Farias et al., 2023).

The results of the ICT in Health 2025 survey indicate that access to computers remains universal in Brazilian healthcare facilities. In 2025, 99% of them used computers, with no differences between the public and private sectors. Regarding the types of devices used, desktop computers remained the most common, present in 97% of facilities, followed by laptops (71%) and tablets (41%).

Significant differences were observed across the administrative spheres and the types of facilities. The use of laptops was more prominent among private facilities (83%) and inpatient facilities with more than 50 beds (91%), indicating their greater presence in larger facilities with greater capacity for technological investment. Tablets usage was more common in public facilities (53%) and Primary Healthcare Units (PHU) (63%), which may be related to the use of these devices in the activities of family health teams.

The survey also investigated the provision of mobile devices to healthcare facilities' professionals. In 2025, 76% of facilities reported providing laptops, tablets, and/or mobile phones to their workers. This practice was more frequent in inpatient facilities with more than 50 beds (84%), private facilities (80%), and those located in the South (79%) and Center-West (78%) regions.

Internet access has expanded in recent years, and in 2025, 99% of Brazilian healthcare facilities used the Internet, with a similar proportion between public and private units. This scenario highlights the consolidation of connectivity as an essential element for the functioning of health services, enabling the use of electronic information systems, communication between professionals, and access to digital management and care platforms.

Regarding connection types, fiber optics and cable remained the predominant options, present in 96% of facilities. Furthermore, mobile connectivity has also been gradually increasing in recent years, rising from 28% in 2015 to 49% in 2025. These results point to a trend, observed throughout the historical series of the survey, of gradual replacement between connection technologies. While fiber optics has expanded its presence since 2019, technologies such as DSL and radio connection have shown significant reductions, falling from 52% to 36% and from 20% to 3%, respectively, between 2015 and 2025 (Chart 1).

CHART 1

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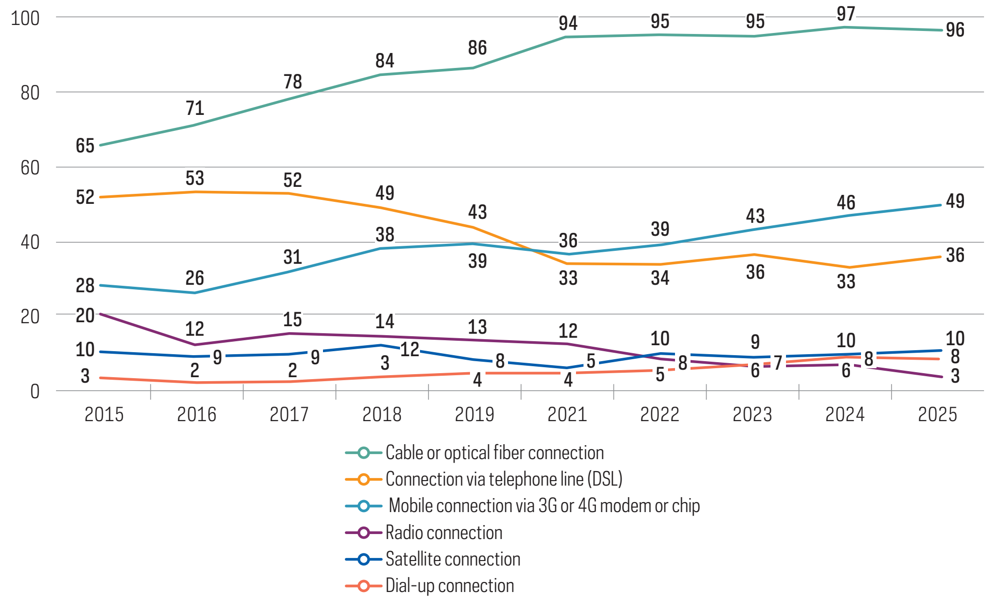
Healthcare facilities with Internet access, by type of connection (2015–2025)

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



Another relevant aspect of digital infrastructure refers to the Internet connection speed contracted by healthcare facilities. In 2025, 48% of facilities had Internet capacity greater than 100 Mbps, with 100 to 300 Mbps being the most commonly adopted range (14%). However, the distribution of this connectivity capacity varied among the different types of facilities, as 63% of private facilities had speeds above 100 Mbps, with a lower proportion in public facilities (30%). Furthermore, inpatient facilities with more than 50 beds showed the highest percentage of high-speed connections (76%) (Chart 2), reflecting differences in investment capacity and a greater demand for technological infrastructure due to the complexity of the services provided.

It is noteworthy that more than half of PHU managers were unable to answer what their contracted Internet speed was (53%). This may be because, in this type of facility, contracts are generally made through the secretariats of health. Therefore, it is important for facilities to adopt tools for monitoring Internet speed and other network characteristics, which will help managers verify whether the contracted plans and speeds meet the facilities' needs.

BOX 1

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CONNECTIVITY IN HEALTHCARE AND SIMET-SAÚDE

The Connectivity in Healthcare project, coordinated by the Brazilian Network Information Center (NIC.br) in partnership with the National Council of Municipal Health Secretaries (Conasems) and the Brazilian Ministry of Health, aims to support improvements in Internet connectivity in public healthcare facilities, contributing to the enablement of digital services such as electronic health records and telehealth. As part of this initiative, SIMET–Saúde is used to measure the quality of connectivity in health units, generating indicators such as speed, latency, packet loss, and jitter. These data make it possible to monitor the digital infrastructure of healthcare services and support the formulation of policies aimed at expanding and improving Internet access in the sector.

CHART 2

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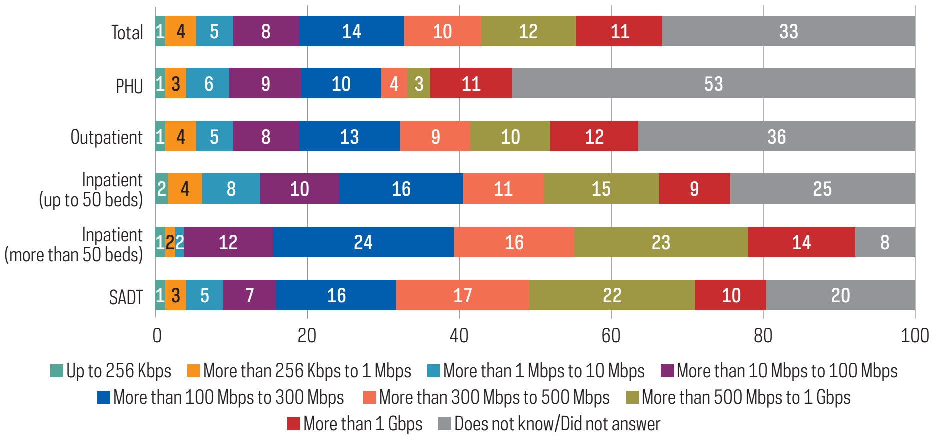
Healthcare facilities with Internet access, by range of download speed of the main connection (2025)

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



The survey also investigated managers' perceptions of the adequacy of the technological infrastructure available in their facilities. In 2025, 53% of managers agreed that the available IT equipment was new and up-to-date, while 65% stated that the Internet connection was adequate for the healthcare facility's needs. Significant differences were observed between the types of facilities, as managers of private facilities (80%), those in capital cities (77%), and those in diagnosis and therapy services (SADT) (82%) tended to evaluate the quality of the available Internet connection more positively. Among public facilities (35%) and PHU (36%), perceptions about the available IT equipment being new and up-to-date were less favorable.

These results suggest that, although basic access to digital technologies is widespread in healthcare facilities, ensuring the quality and suitability of the infrastructure to meet the needs of different types of care remains a challenge. The literature indicates that limitations related to technological infrastructure continue to be among the main obstacles to the consolidation of digital health in several countries, especially in primary care services (Farias et al., 2023; Silva Jr. et al., 2025; Soibelman et al., 2025).

Furthermore, infrastructure demands can vary depending on the profile of healthcare facilities. In the case of PHU, for example, they tend to require mobile devices and solutions that facilitate monitoring the populations in their territories, while hospitals that perform more complex procedures need greater processing capacity, faster connections, and greater availability of technological devices. Studies on telehealth indicate that many units still face difficulties related to connectivity and equipment availability, which may limit the expansion of remote care and digital monitoring initiatives (Catapan et al., 2024).

In this scenario, expanding technological infrastructure can take into account the specificities of different levels of health care and the inequalities between public and private facilities, in order to favor more suitable conditions for the implementation and expansion of digital health services.

Electronic health records and information exchange

The digitalization of clinical records is a central component of the digital transformation in health care. The use of electronic health records allows more systematic organization of patient information, tracking of care pathways over time, and support for clinical and managerial decision-making. Furthermore, these medical records can contribute to the integration of information between different facilities within the healthcare network.

However, the integration of health information remains one of the main challenges to the development of digital health. Several studies indicate that health systems often operate with fragmented databases and applications developed for specific purposes, which hinders interoperability and limits the strategic use of information for management and decision-making (Fornazin et al., 2022). The adoption of interoperable electronic health records and the establishment of common standards for data exchange are fundamental aspects for improving the quality of health information and strengthening care coordination between different levels of care (Farias et al., 2023).

The results of the ICT in Health 2025 survey indicate that 92% of healthcare facilities used electronic systems to record patient information, a proportion that remained stable compared to the previous edition. This result reflects the gradual expansion of computerization in the healthcare sector observed over the last decade. In the last period, there were variations among inpatient facilities with up to 50 beds (from 78% to 81% between 2024 and 2025) and in SADT (from 94% to 96% in the same period), as shown in Chart 3.

CHART 3

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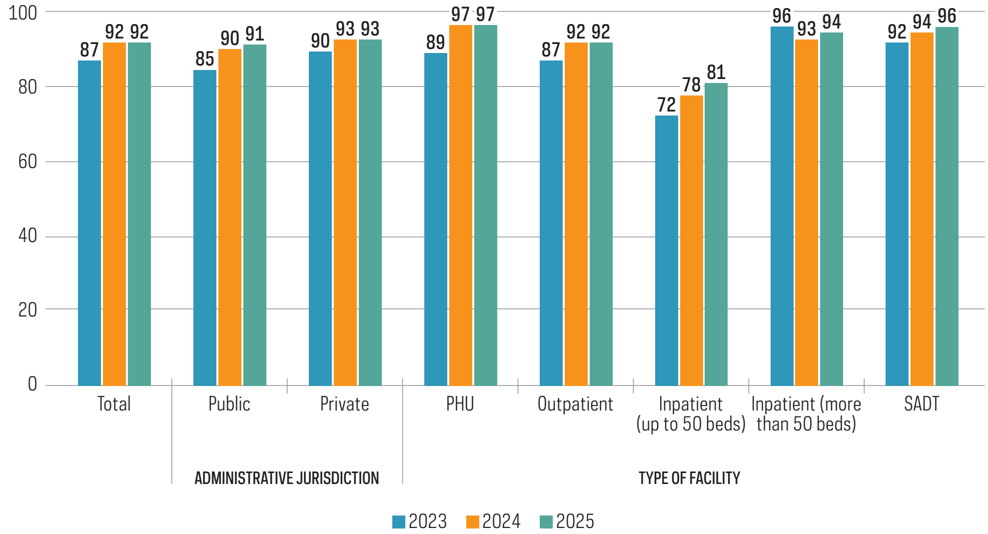
Healthcare facilities by availability of electronic systems to record patient information (2023–2025)

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



Despite the widespread use of electronic systems, the way clinical and registration information is stored reveals that many facilities still operate on hybrid models. In 2025, 55% of facilities kept patient information in a partly paper-based and partly electronic format, while 37% stored this information exclusively electronically, and only 5% maintained records solely on paper. It is noteworthy that a higher percentage of inpatient facilities had records in both formats (69% of inpatient facilities with up to 50 beds and 80% of those with more than 50 beds), while the exclusive use of the electronic format corresponded to 13% in inpatient facilities with up to 50 beds and 14% of those with more than 50 beds.

The use of hybrid records may reflect factors such as limitations in technological infrastructure, administrative requirements, or difficulty in adapting workflows to the complete digitalization of information. Studies on the implementation of digital health in the SUS indicate that the adoption of electronic systems occurs heterogeneously among facilities and frequently coexists with administrative and clinical practices still based on physical records (Fornazin et al., 2022).

The availability of patients' clinical data in electronic format was also investigated by the survey. The results indicate that information related to patient demographics (92%), detailed clinical notes from encounters with clinicians or medical history (82%), and patients' diagnoses, health problems, or conditions (79%) are available electronically in most healthcare facilities (Chart 4). The only category of information present in less than half of the health units was radiology tests (images) (38%), which may reflect greater technological complexity and the volume of storage required for this type of data.

CHART 4

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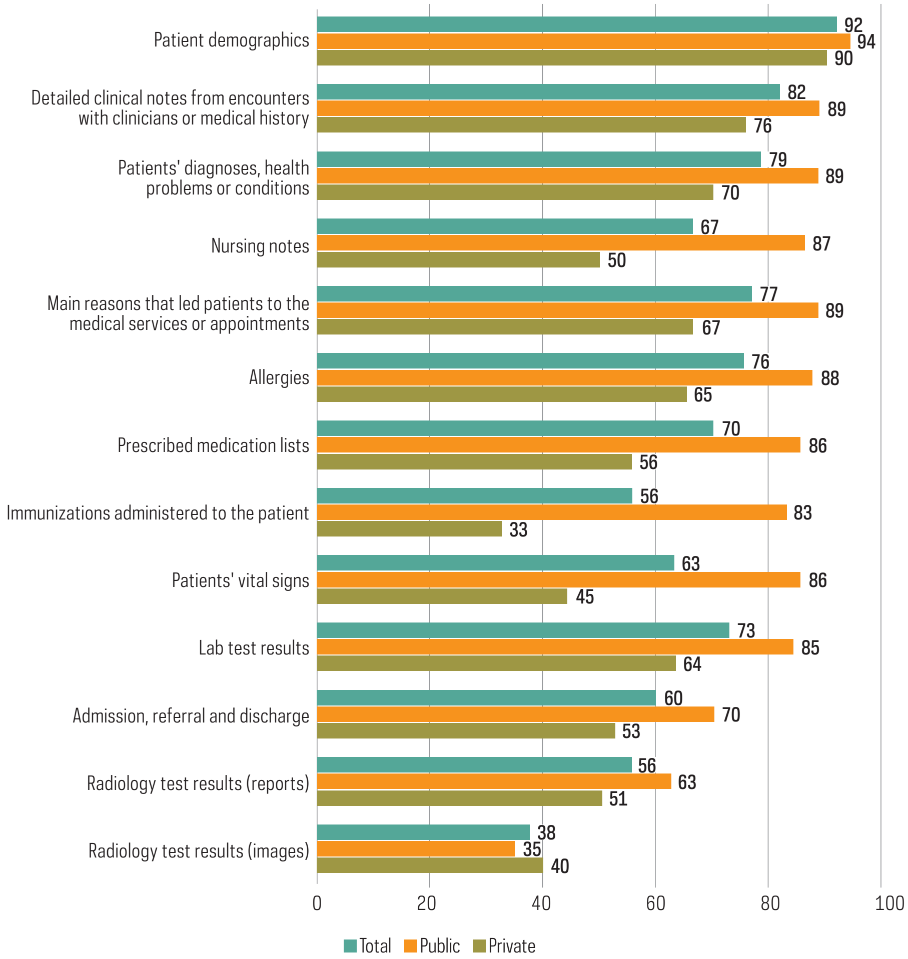
Healthcare facilities by type of patient data available electronically (2025)

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



One important feature observed in the 2025 edition relates to the differences between public and private sector facilities in the electronic availability of clinical information. For several types of data investigated, public facilities showed greater availability of information in electronic format than private facilities. Information such as medical history, diagnoses, nursing notes, vital signs, immunization records, and prescribed medication lists were more frequently available in electronic format in public facilities. This result may be related to the adoption of standardized systems in public health networks and their integration with national information systems.

Electronic health systems can offer a variety of functionalities that support both service management and clinical activities. In 2025, the most common functionalities were related to managing care and organizing care flows, such as booking appointments, tests, or surgeries (67%), requesting lab tests (65%), and writing medical prescriptions (63%). These features are relevant for improving administrative efficiency and reducing errors in clinical and operational processes.

Analysis by administrative jurisdiction revealed important differences between public and private facilities. In general, public facilities had greater availability of these functionalities in electronic systems, especially with regard to procedures related to clinical care and medication management, such as those related to prescribing medications (84% of public vs. 46% of private facilities), requesting lab tests (82% vs. 52%), and listing patients by diagnosis (68% vs. 33%).

In addition to administrative and clinical record-keeping functionalities, electronic systems can also incorporate features aimed at supporting clinical decision-making. These resources assist healthcare professionals by providing alerts and recommendations based on clinical protocols or medical evidence.

Despite the importance of these features, they are present in a smaller percentage of healthcare facilities. In 2025, 41% of health units had systems that offered clinical guidelines or care protocols, while about a third had systems with drug allergy alerts (33%), contraindication alerts (31%), or allergies to food and surgical tape alerts (31%). Other features, such as alerts and reminders regarding drug dosage (26%), drug interactions (25%), and drug interference with lab results (22%), appeared in smaller proportions. These results indicate that, although electronic systems are widespread, the incorporation of functionalities aimed at clinical support still occurs on a smaller scale when compared to those aimed at administrative functionalities.

One of the most important dimensions of the digitalization of health systems is the ability to exchange information between different facilities, ensuring greater continuity of care and better coordination between levels of health care. However, many health information systems still operate in a fragmented way, with data stored in isolated systems and without common interoperability standards, which limits the strategic use of information to support decision-making in health (Farias et al., 2023).

In 2025, 44% of facilities reported having electronic systems that allowed them to send or receive electronic referrals to other health units, with this proportion being significantly higher among public facilities (64%) than in private facilities (28%). For all these indicators, a significant difference was observed between the administrative jurisdictions. Electronic information exchange was more frequent in public facilities, as observed in relation to patient referrals (64% of public and 28% of private), in the exchange of discharge summaries (55% and 29%, respectively), and in the exchange of clinical information (53% and 25%, respectively) (Chart 5).

CHART 5

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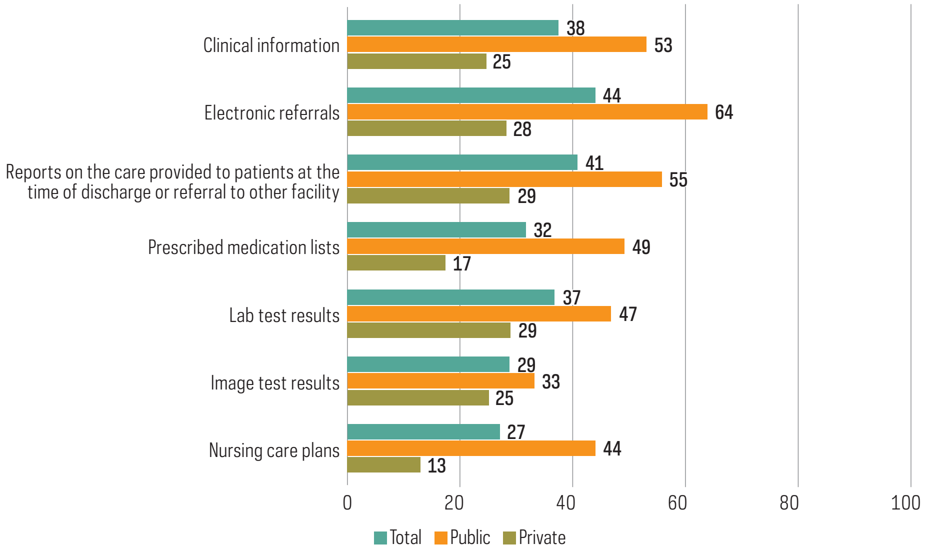
Healthcare facilities by available electronic healthcare information exchange functionalities (2025)

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



In this edition of the survey, ICT in Health began investigating the integration of healthcare facilities into RNDS, a platform established by the Brazilian Ministry of Health with the objective of promoting interoperability between the different health information systems in the country. The RNDS constitutes the national infrastructure responsible for enabling the secure and standardized sharing of clinical data between public and private healthcare facilities, contributing to the integration of healthcare networks and the continuity of patient care.

The creation of the RNDS is aligned with the guidelines of the Digital Health Strategy for Brazil (ESD28), which prioritizes the construction of a national interoperability architecture capable of connecting information systems used at different levels of health care. In this context, the network seeks to enable access to relevant clinical information—such as immunization records, test results, and electronic health record data—regardless of the facility where the care was provided.

The interoperability promoted by the RNDS has the potential to improve the efficiency of health system management and support clinical decision-making. By enabling the sharing of information between different facilities and levels of care, the network helps to reduce duplication of tests, improve care coordination, and expand the availability of data for planning and monitoring health policies.

The results of the ICT in Health 2025 survey indicate that 44% of healthcare facilities that used the Internet are integrated into the RNDS. Integration was more common in PHU (72%) and in public sector facilities (64%) (Chart 6). In addition, healthcare facilities in the North (53%) and Northeast (50%) presented greater integration with the network. These results indicate the strengthening of the role of public health care networks in implementing national interoperability policies and in the use of integrated health information systems.

CHART 6

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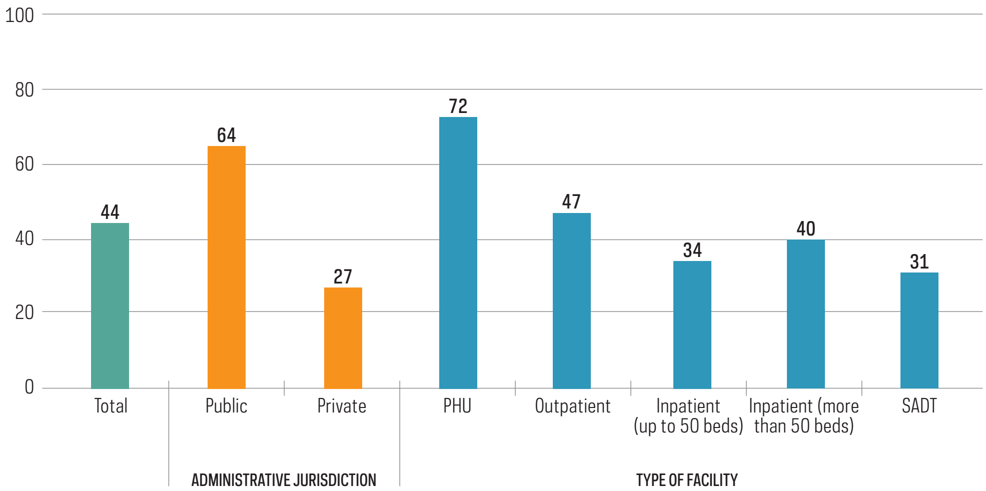
Healthcare facilities by integration to the RNDS (2025)

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



The digitization of clinical information is already widespread in Brazilian healthcare facilities, with a broad presence of electronic systems for recording patient information and the availability of clinical data in electronic format. However, the presence of electronic systems alone does not guarantee the integration of information throughout the healthcare network. Therefore, initiatives focused on interoperability become fundamental so that electronically recorded data can be shared by different health units and used more efficiently in patient care, service management, and the planning of public health policies.

Governance and information security

IT governance refers to the set of organizational structures, processes, and responsibilities that guide the management of technological resources in institutions.

With the increasing use of digital technologies in healthcare facilities, it has become ever more necessary to strengthen information governance and data protection mechanisms. Electronic health record systems, telehealth platforms, and other digital solutions involve the storage, processing, and sharing of sensitive patient health data, which requires appropriate information security measures and compliance with regulatory frameworks, such as the Brazilian General Data Protection Law (LGPD). This strengthening of data governance constitutes an essential component of digital health strategies, contributing to ensuring the confidentiality of information and the responsible use of health data (Catapan et al., 2024; Farias et al., 2023).

Furthermore, the increasing digitalization of healthcare services has significantly expanded the volume of sensitive data produced by information systems. In this context, there is an increasing need for robust governance mechanisms capable of preventing the misuse of this information and reducing risks associated with data security, given its high economic value and discriminatory potential (Haddad & Lima, 2024).

IT management in healthcare facilities can take on different institutional arrangements, ranging from the presence of specialized departments or areas to the contracting of external technological support services. Considering all facilities in 2025, 24% had IT departments or areas, while the same proportion (24%) contracted service providers directly. In 32% of cases, IT management was carried out by service providers contracted by the secretariats of health—which was mainly due to public facilities, including PHU (75%).

The differences between the administrative jurisdictions were quite significant. Among public facilities, IT management was predominantly carried out through service providers contracted by the secretariats of health (69%), indicating that technological infrastructure and technical support tended to be centrally organized within public networks. In this model, the responsibility for maintaining information systems, managing digital infrastructure, and supporting network units often fell to municipal or state secretariats of health. In contrast, private facilities showed greater autonomy in organizing technological management. In this group, 43% hired service providers directly, 33% had their own IT departments or areas, and 12% had in-house staff of the healthcare facilities that were responsible for the technological area, reflecting greater investment capacity and greater administrative flexibility to structure teams or hire specialized services.

CHART 7

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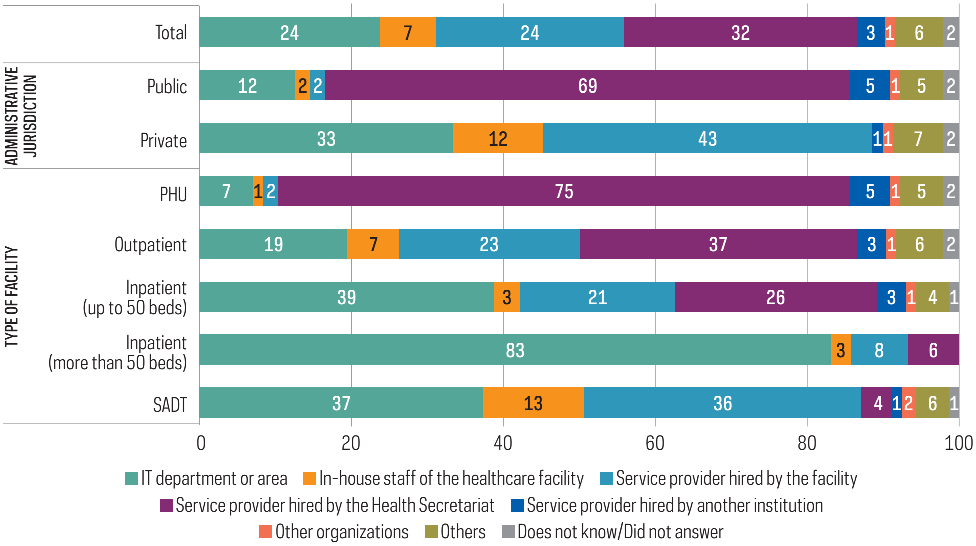
Healthcare facilities by main person responsible for IT (2025)

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



Analysis shows that the organization of IT management varied according to the type of facility, complexity, and responsibilities of healthcare services. In PHU, technological management was mostly carried out through service providers contracted by the secretariats of health (75%), reflecting the centralization of technological support in municipal primary care networks. A greater diversity of arrangements was observed among outpatient facilities, , with 37% using providers contracted by the secretariats of health, 23% contracting services directly, and 19% having their own IT departments or areas, which highlights the heterogeneity of this group.

Among inpatient facilities, the presence of internal technology infrastructure increased with size: 39% of those with up to 50 beds had IT departments or areas, a proportion that reached 83% in those with more than 50 beds, indicating the presence of greater technological complexity in hospitals. In SADT, there was also a significant presence of in-house infrastructure (37%) or direct contracting of IT services (36%), associated with the intensive use of specialized systems and equipment.

Overall, the results indicate that the organization of IT management in healthcare units is quite closely associated with the type of service provided, the type of facility, and the organizational model of healthcare networks. Hospitals with greater care complexity tend to structure internal teams or departments/areas dedicated to technology, while smaller units or those integrated into public networks often depend on centralized technological support structures, especially those coordinated by secretariats of health.

The incorporation of digital technologies into healthcare services also requires the development of specific skills on the part of the managers responsible for the implementation and management of these systems. Training in health informatics can contribute to expanding the capacity for planning, coordination, and governance of digitization initiatives in the sector.

The survey results indicate that, in 2025, 40% of managers reported having participated in training or capacity-building related to these skills, 12% took specialization courses, 7% reported taking some other course or capacity-building in the area, and only 1% had a master's degree. This data suggests that, although capacity-building initiatives exist, structured training in health informatics is still relatively limited among managers responsible for leading digitalization processes in health units. Managers of inpatient facilities with more than 50 beds were the most likely to have some type of training in the field of health informatics (61%).

Among managers who had received some type of training in health informatics, the most frequent topics were related to the structure and functioning of health services organizations (71%) and interdisciplinary team management (67%), followed by resource management (55%), risk management (54%), and health policies and regulatory frameworks (53%). These results indicate that the training received tends to prioritize content related to the organization of services and management in healthcare. On the other hand, topics more directly associated with information technology governance were less frequently covered in training. Only 36% of managers who received any training in the field studied content related to cloud or edge computing, 31% on technology-business alignment, and 25% on network architectures and topologies.

In general, although there was some level of training in health informatics among facility managers, there is still room to expand training in topics related to digital governance, system architecture, and information technology management. Expanding these skills can contribute to improving the implementation of digital solutions, supporting the management of health information systems, and strengthening governance processes in the context of the sector's digital transformation.

DATA PROTECTION AND INFORMATION SECURITY

Protecting patients' sensitive personal data requires the adoption of institutional policies, technological security tools, and training for professionals responsible for the use and management of this information. The expansion of digital health involves the processing and sharing of large volumes of sensitive data, which makes the development of appropriate policies and regulatory frameworks even more crucial to ensure the security, confidentiality, and responsible use of health information (Farias et al., 2023). In the case of Brazil, the discussion about health data governance also involves the need to align digital health initiatives with the principles of SUS, ensuring that the use of digital technologies contributes to strengthening universal and equitable access to health services (Fornazin et al., 2022).

The results of the ICT in Health 2025 survey indicate that 42% of healthcare facilities had information security policies. Here, too, differences were observed between public (28%) and private (54%) facilities, as well as differences between their types: outpatient facilities (38%) and inpatient facilities with up to 50 beds (40%) showed lower percentages compared to those with more than 50 beds (72%) and SADT (64%). These results have not shown significant variations in recent years, highlighting that there is still a significant portion of facilities that do not have formal, structured policies on this topic, which may represent risks related to the use and storage of sensitive data.

In addition to institutional policies, the survey also investigated the rate of adoption of security tools aimed at protecting digital infrastructure and data stored in electronic systems. Among the most common measures were the use of antivirus software (84%) and password-protected access (83%), practices considered basic for the protection of information systems. On the other hand, more sophisticated security tools or those requiring greater technical implementation capacity showed lower adoption rates. The use of database cryptography (42%), for example, was less frequent than basic system protection measures. This indicator also showed differences by administrative jurisdiction, with a higher percentage of private facilities adopting information security tools when compared to public facilities (Chart 8).

CHART 8

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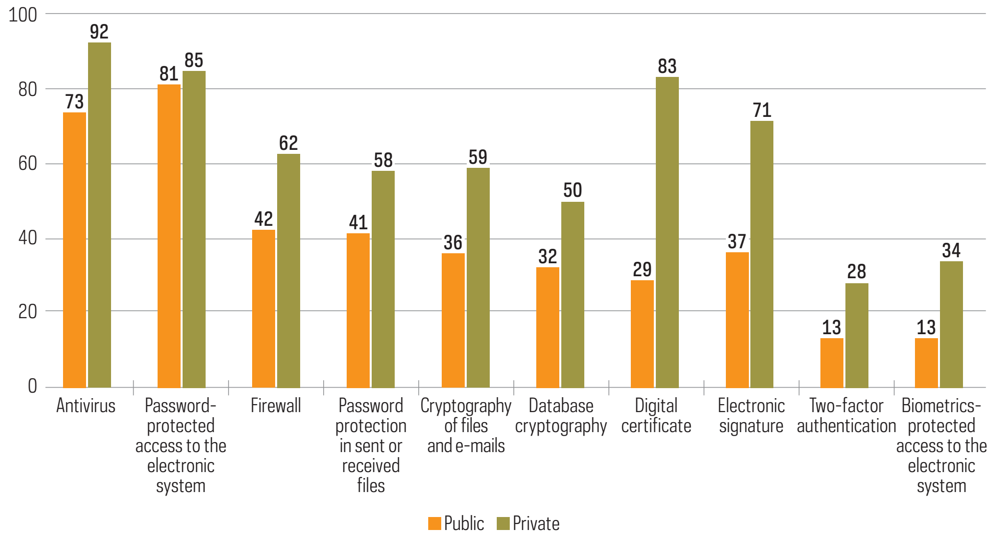
Healthcare facilities by type of information security tool used (2025)

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



It is noteworthy that, in addition to the use of technological tools to enhance the protection of electronic systems, information security also requires governance processes capable of ensuring the confidentiality, integrity, and availability of health data (Kruse et al., 2017). Therefore, training of professionals who use digital systems also plays an important role in reducing vulnerabilities related to the everyday use of technologies. In 2025, 47% of facilities reported having provided information security training for their staff. This type of training is particularly important for reducing risks associated with human error, such as improper sharing of information, misuse of systems, and exposure of sensitive data.

The adaptation of healthcare facilities to the requirements of the LGPD is an important element of data governance in the context of the digitalization of healthcare services. Brazilian legislation establishes guidelines for the processing of personal data, including sensitive health-related data, and provides for the adoption of organizational and technical measures to ensure the protection of this information (Law No. 13.709/2018). The results of the ICT in Health 2025 survey indicate that less than half of the facilities have adopted initiatives related to the implementation of the law.

Overall, 46% of healthcare facilities carried out internal awareness campaigns about the LGPD for their employees, making this the most common practice among those investigated in the survey. The remaining data protection measures were adopted by a smaller percentage, reaching approximately one-third of facilities. Significant differences were also observed when considering the administrative jurisdiction. The availability of online customer service channels for data subjects, for example, was present in 19% of public facilities and 40% of private facilities. Similarly, internal awareness campaigns about the LGPD were conducted in 30% of public facilities and 58% of private facilities, while the implementation of response plans for information security incidents related to personal data was reported by 15% of public facilities and 42% of private facilities.

Analysis by type of facility reveals important differences in the adoption of practices associated with the LGPD. The highest proportions of adoption of the investigated measures were observed for SADT and inpatient facilities with more than 50 beds, such as carrying out internal awareness campaigns on the LGPD (69% in SADT and 59% in inpatient facilities with more than 50 beds) and appointing a Data Protection Officer for the facility (56% and 49%, respectively). These facilities also showed higher proportions for making online customer service channels available for data holders and implementing response plans for information security incidents related to personal data. In contrast, PHU showed the lowest proportions in most indicators, such as assigning a Data Protection Officer (11%) and implementing response plans for information security incidents (14%), as shown in Chart 9.

CHART 9

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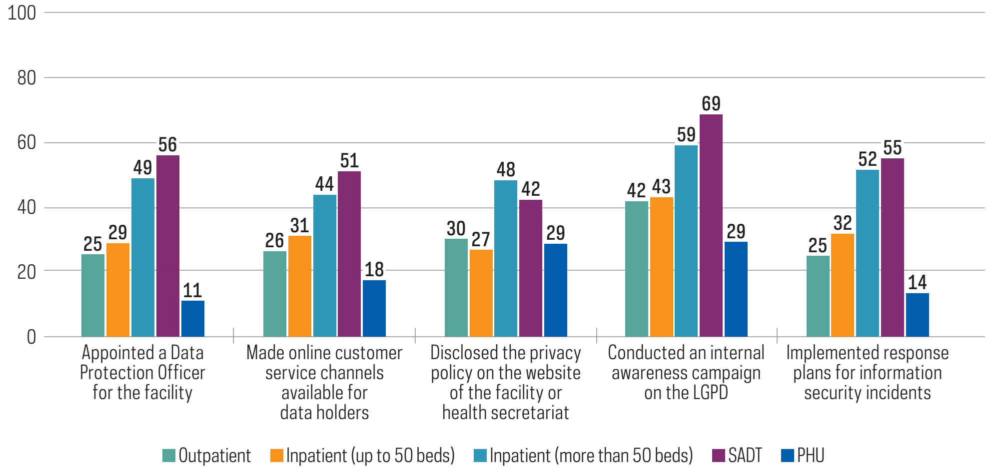
Healthcare facilities by measures adopted concerning the LGPD, by type of facility (2025)

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



The results indicate that the adoption of data protection measures was associated with the type of facility and the level of complexity of care, being more frequent in specialized facilities than in PHU. Some studies indicate that a significant portion of security incidents in health information systems are related to inadequate usage practices by their users, such as operational failures, non-compliance with protocols, or poor adherence to best practices, which reinforces the importance of training and awareness strategies (McLeod & Dolezel, 2018).

In general, although basic information security measures are widespread in healthcare facilities, there is still much room for improvement in the institutionalization of information security policies and the training of professionals. Strengthening these practices is becoming increasingly necessary given the expansion of the digitalization of health services and the growing circulation of clinical data in digital environments, especially in the context of interoperability initiatives and information sharing among healthcare facilities.

Online presence, digital services for patients, and telehealth

The online presence of healthcare facilities and the provision of digital services to patients are increasingly important dimensions of the digital transformation in the sector. The availability of institutional channels on the Internet, such as websites and social media, expands the possibilities for communication with the population and facilitates access to reliable and qualified information about services, business hours, and health guidelines. Furthermore, digital platforms can serve as a gateway for offering online services, such as booking appointments and accessing test results. The use of these tools can contribute to improving the patient's digital experience and increasing efficiency in the management of health services (Organisation for Economic Co-operation and Development [OECD], 2023; WHO, 2019).

The results of the ICT in Health 2025 survey indicate that 48% of healthcare facilities had websites. Institutional presence on the Internet varied significantly depending on the administrative level and type of facility. Among private facilities, 73% had websites, while in public facilities that proportion was only 18%. This difference may reflect both the more frequent use of digital communication channels by private institutions and the centralization of institutional communication by public units on portals maintained by secretariats of health.

Discrepancies also appeared when considering the type of facility. Among SADT, 75% had websites, a proportion similar to that observed among inpatient facilities with more than 50 beds (73%). This may reflect the increased demand for service dissemination, access to test results, and resources for investment in this area. In outpatient facilities and inpatient facilities with up to 50 beds, the proportion was approximately 45%. As for PHU, only 16% had websites, which may be related to the fact that many of these units use institutional pages of municipal or state health secretariats to disseminate information.

In addition to institutional websites, many healthcare facilities also used social media as a communication channel with patients and the general public. In 2025, 57% of facilities had their own profiles or accounts on social networks, a higher proportion than that observed for institutional websites (48%). As with websites, social media presence was significantly higher among private facilities (84%) than among public facilities (24%). Regarding the type of facility, the highest proportions were observed among inpatient facilities with more than 50 beds (81%) and for SADT (80%), while outpatient facilities and inpatient facilities with up to 50 beds showed lower proportions (53% and 58%, respectively).

These results indicate that social networks have become established as an important digital communication channel in the healthcare sector, often complementing or replacing institutional websites, especially among private facilities and specialized services.

ONLINE SERVICES OFFERED TO PATIENTS

Offering online services directly aimed at patients—such as booking appointments, viewing test results, and interacting with medical teams—represents one of the key dimensions of the digitalization of healthcare services. These tools can facilitate access to services for the population, reduce administrative barriers, and improve the patient experience when interacting with healthcare facilities, especially when combined with telehealth and remote care initiatives (Catapan et al., 2024; WHO & PAHO, 2023).

The survey results indicate a gradual increase in the availability of these online services to patients in recent years. The most frequently offered service, viewing lab test results, increased from 33% in 2023 to 39% in 2025, while booking appointments increased from 30% to 34% and booking tests from 27% to 32% (Chart 10). The most significant growth was observed in interaction with medical teams, which increased from 16% in 2023 to 35% in 2025, suggesting greater use of digital communication channels between patients and healthcare professionals.

CHART 10

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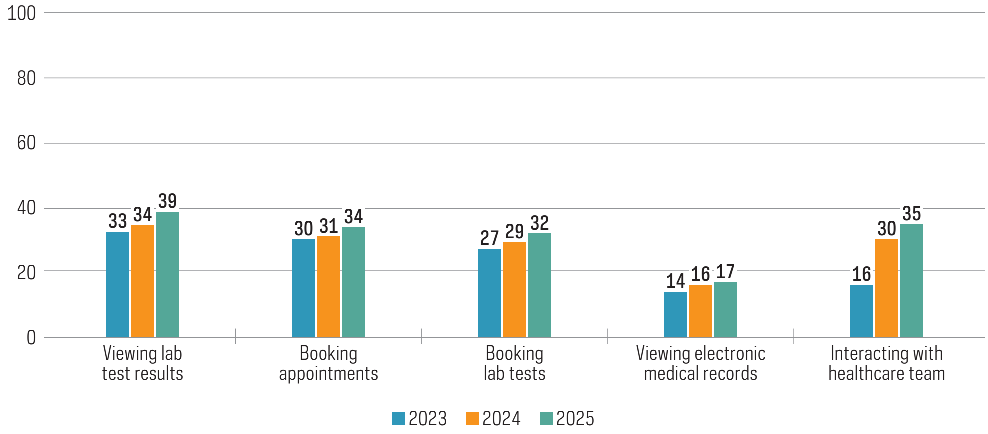
Healthcare facilities by online services offered to patients (2023–2025)

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



The range of online services offered varies depending on the type of facility, reflecting the characteristics of the services provided and the specific needs of each service. In healthcare units focused on diagnosis and examination, such as SADT, there was greater availability of services related to management of and access to tests. In this group, 72% of the units allowed online viewing of test results and 52% offered online booking of tests, proportions significantly higher than those observed in other types of facilities. On the other hand, PHU presented a higher proportion of services such as online interaction with medical teams (42%) and viewing electronic health records (25%). This result may be related to the role of these units in coordinating care and providing longitudinal follow-up for patients within the context of primary care. Among outpatient facilities, approximately 37% offered online booking of appointments, while inpatient facilities with up to 50 beds tended to have lower proportions in several of the services analyzed.

TELEHEALTH AND ITS ADOPTION BY HEALTHCARE PROFESSIONALS

The use of telehealth services has been expanding in health systems in different countries as a strategy to broaden the population's access to health care, especially in contexts of territorial inequality in the distribution of health services and professionals (WHO, 2019). The different modalities of telehealth can contribute to reducing geographical barriers to access to health services, improving integration between different levels of care, and expanding clinical support for professionals working in regions with less availability of specialists (Bashshur et al., 2020).

In Brazil, the development of telehealth has been favored by both technological advances and public policy initiatives aimed at digital transformation in the health sector. Programs such as Telessaúde Brasil Redes (Telehealth Brazil Networks) and the Estratégia de Saúde Digital para o Brasil 2020-2028 (Digital Health Strategy for Brazil 2020–2028) seek to strengthen the use of these technologies to support primary care, expand the qualification of health professionals, and improve the population's access to services (Brazilian Ministry of Health, 2020).

In recent years, new initiatives have broadened this agenda. Within the scope of the SUS Digital Program (Brazilian Ministry of Health, 2024) and the Health Axis of the New PAC (Civil House of the Presidency of the Republic, 2023), the Brazilian Ministry of Health established financial incentives for the structuring of telehealth services in healthcare facilities, especially in primary care. These services correspond to SUS facilities that now have the infrastructure and equipment to carry out telehealth actions and services, such as teleconsultations, teleconsulting, and telediagnosis. To support this structuring, municipalities can receive specific resources earmarked for the implementation of these services, with investment focused on the acquisition of equipment and the organization of digital health services. Additionally, the Agora Tem Especialistas program seeks to expand the population's access to specialized consultations, exams, and surgeries through the use of telehealth, contributing to the reduction of waiting lists and regional inequalities in access to specialized care (GM/MS Ordinance No. 7.495/2025).

In line with the advancement of public policies in this area, the 2025 results indicate an increase in the percentage of healthcare facilities that provide these services. Teleconsulting, which is the exchange of information between healthcare professionals to support clinical decision-making, was the most widespread service, present in 36% of facilities in 2025, above the 30% recorded in 2024 and 27% in 2023, as shown in Chart 11. Teleconsultation, which involves direct patient care through digital technologies, also showed growth, increasing from 22% in 2023 to 28% in 2025. Other services were also expanded during the period—such as telediagnosis, which increased from 21% to 27%, and telemonitoring, which went from 14% to 20%—indicating a gradual increase in the use of these technologies in the remote monitoring of patients.

CHART 11

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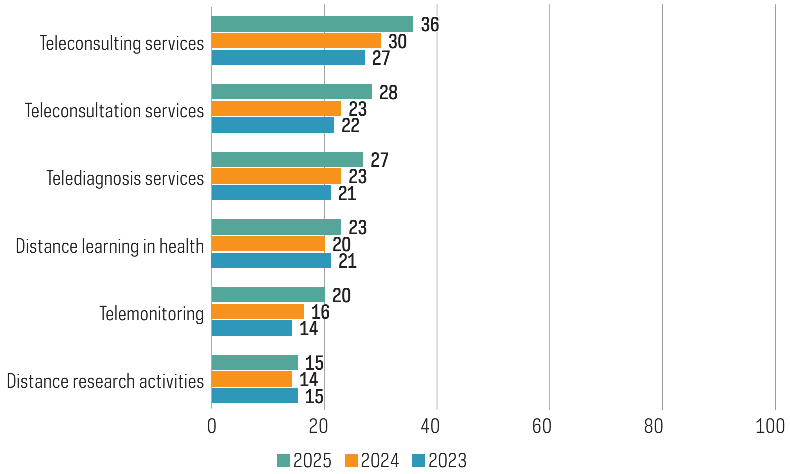
Healthcare facilities by telehealth services (2023–2025)

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



These results suggest that telehealth practices are becoming progressively established in the Brazilian healthcare system, favored both by the evolution of digital technologies and by implemented policies and recent regulatory changes. The expansion of these modalities can contribute to broadening access to specialized services, improving communication between healthcare professionals, and supporting the monitoring of patients at different levels of care, especially in regions with less availability of in-person services (Soibelman et al., 2025).

Despite this progress, telehealth still faces challenges related to technological infrastructure, the organization of work processes, and regulatory frameworks within public health systems. Addressing these challenges are critical to prevent teleconsultation initiatives from being implemented in a decentralized manner on platforms that do not fully meet security and data protection requirements (Catapan et al., 2024).

Adoption of emerging technologies in healthcare facilities

Emerging data-driven technologies, such as cloud services, Big Data, and AI, are expanding in the healthcare sector and opening up new possibilities for service management, clinical information analysis, and decision support. These tools allow for the processing of large volumes of data from different sources—such as electronic health records, diagnostic tests, connected devices, and administrative systems—and transform them into useful information to improve the quality of care, optimize care flows, and support the management of health systems. The most common applications include support for diagnostic imaging, analysis of clinical data for the identification of disease patterns, remote patient monitoring, and the automation of administrative and logistical processes (OECD, 2023; Raghupathi & Raghupathi, 2014).

In Brazil, the advancement of these technologies has been accompanied by public policy initiatives aimed at digital transformation in the sector. More recently, Federal Council of Medicine (CFM) Resolution No. 2.454/2026 began to regulate the use of AI in medicine, establishing principles for the development, governance, and responsible use of these tools. Among the main points, the resolution requires AI systems to act as tools to support medical practice, preserve professional autonomy, and ensure that final clinical decisions remain the responsibility of physicians, in addition to requiring transparency, monitoring, and protection of the health data used in these systems.

The 2025 edition of ICT in Health also introduced a methodological shift in the investigation on the use of digital technologies. Until 2024, questions related to the use of Big Data and AI only applied to facilities that had IT departments or areas. Considering that these tools have become increasingly accessible—being available for purchase or contracted as external services, often without the need for specialized internal structures—the survey began to investigate these indicators among all facilities that had computers, broadening the scope of the analysis on the use of emerging digital technologies in the health sector.

The ICT in Health 2025 results indicate that some cloud services investigated by the survey were adopted by more than half of the healthcare facilities, especially e-mail (63%) and file storage or databases (57%). Processing capacity (38%) and office software (32%) in the cloud were part of the routine for a smaller percentage (Chart 12).

CHART 12

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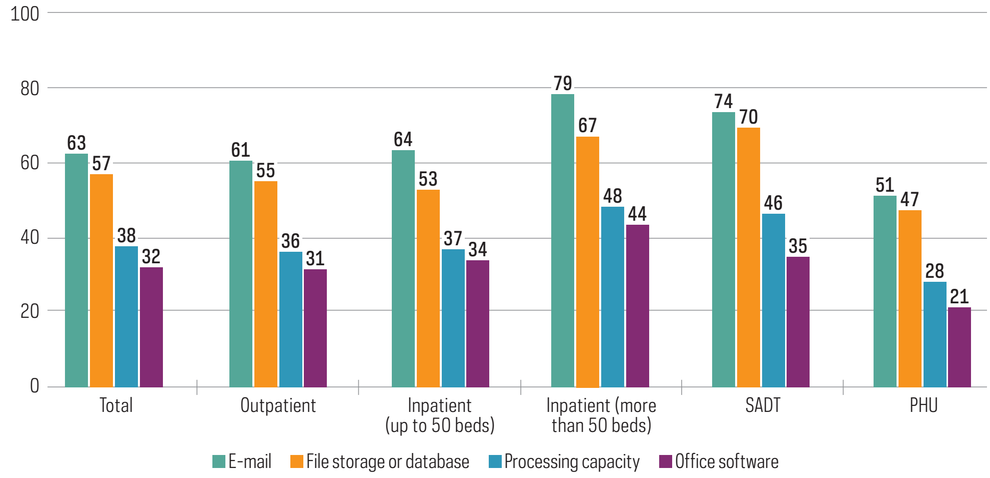
Healthcare facilities that used cloud services, by type of facility (2025)

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



The adoption rates of these services show significant differences according to administrative jurisdiction. In all the indicators analyzed, private facilities showed higher levels of use of cloud services. Among them, the cloud-based services used included: e-mail, 69%; data storage, 65%; processing capacity, 45%; and office software, 41%. In public healthcare facilities, these proportions were lower, reaching 55%, 48%, 29%, and 22%, respectively.

Differences were also observed by type of facility, with inpatient facilities with more than 50 beds showing the highest proportions of use in most of the cloud services investigated. On the other hand, PHU showed lower adoption levels of these technologies. SADT also presented high levels of use, particularly for data storage and cloud processing capabilities, which may be associated with the large volume of data generated by diagnostic tests and imaging systems.

In 2025, 9% of facilities conducted Big Data analytics. As with other more advanced digital technologies, there were significant differences depending on the administrative jurisdiction and the type of facility. Among private healthcare facilities, 11% conducted Big Data analytics, while among public facilities this proportion was 6%. The differences were even more pronounced when considering the type of facility. Among inpatient facilities with more than 50 beds, 30% performed Big Data analytics, a significantly higher proportion than observed in other types, such as SADT (13%), inpatient facilities with up to 50 beds (11%), outpatient facilities (7%), and PHU (5%).

Among the facilities that conducted Big Data analytics, these practices were strongly associated with the use of data generated internally, such as patient demographics, forms, and medical records (76%), and information from smart devices or sensors (65%). Other sources used included geolocation data (48%) and data generated from digital media (57%). These results indicate that Big Data analytics were more closely linked to the use of clinical and administrative data produced within the facilities own care delivery and operational activities. Finally, approximately 70% of these analytics were performed by in-house staff.

Technologies such as the Internet of Things (IoT) and robotics are also investigated by ICT in Health. IoT refers to the use of Internet-connected devices capable of automatically collecting and transmitting data, such as connected medical equipment, sensors for patient monitoring, and devices used in hospital management. Robotics, on the other hand, involves the use of automated systems that can assist in medical procedures, surgeries, rehabilitation, or logistical and operational activities within healthcare services.

In 2025, 9% and 5% of healthcare facilities used IoT and robotics, respectively. As observed with other emerging digital technologies, the results indicate differences between the types of healthcare facilities. Among inpatient facilities with more than 50 inpatient beds, 15% used IoT and 14% robotics, while 10% and 17% of SADT employed these tools, respectively. In other types of facilities, usage remained more limited, with less than 10% reporting such use.

ARTIFICIAL INTELLIGENCE

AI-based applications have been employed in areas such as supporting diagnostic imaging, analyzing clinical records, monitoring patients, organizing care flows, and managing health services. The advancement of these applications stems from the increased availability of health data, the expansion of digital infrastructure, and the development of computational models capable of processing large volumes of information, contributing to improved clinical decision-making and the management of health systems (OECD, 2023).

In this context, AI has stood out for its potential to support the identification of patterns in large databases and the development of predictive models applied to health care. Recent studies demonstrate that machine learning techniques can be used to identify risks and support clinical decisions in different care contexts, contributing to improving the efficiency and quality of care (Silva et al., 2025). These applications expand the possibilities for using health data, especially in systems that seek to strengthen evidence-based decision-making.

Despite this potential, incorporating this technology also presents significant challenges. Its use requires the construction of a regulatory environment capable of ensuring usage based on quality, safety, and the benefit of patients. Its expansion in health care raises significant challenges related to the transparency of algorithms, data governance, and the protection of sensitive information. Some studies highlight that algorithm-based systems can reproduce existing inequalities when trained with historical data, which reinforces the importance of adequate governance and oversight mechanisms (Haddad & Lima, 2024). In Brazil, the LGPD has already become an important milestone in this process, establishing rights related to the automated processing of personal data, including the possibility of reviewing decisions based on automated processing (Dourado & Aith, 2022).

Rapid technological evolution has been accompanied by increasing debates about data governance, information security, and the training of healthcare professionals for the proper use of these tools. In this scenario, strengthening the capacity for data analysis and use in healthcare systems becomes a central element in enabling the incorporation of AI. Data monitoring and analysis strategies can contribute to improving the management and planning of healthcare networks, as well as supporting the more efficient use of digital technologies in the sector (Chiavegatto Filho & Barros, 2023).

In recent years, various initiatives have sought to stimulate the development and incorporation of advanced digital technologies into the Brazilian healthcare system. Among them, the Brazilian Ministry of Health's proposal to create the National Network of Intelligent Hospitals and Services of the SUS stands out, which foresees investments for the modernization of hospital units, implementation of intelligent ICUs, and development of a high-tech hospital focused on the intensive use of data, AI, and integrated digital systems in serving the population (Brazilian Ministry of Health, 2025). These initiatives aim to expand the technological capacity of the healthcare system, strengthen large-scale data analysis, and support the incorporation of digital solutions capable of improving the efficiency of services and the quality of care.

In this regard, CFM Resolution No. 2.454/2026 began to regulate the use of AI in medicine in Brazil, establishing principles for its development, governance, and responsible use. The regulation stipulates that AI systems must act as tools to support medical practice, preserving professional autonomy and ensuring that the final clinical decision remains the responsibility of the physician, in addition to establish guidelines related to the transparency, monitoring, and protection of health data used in these solutions.

The results of the ICT in Health 2025 survey indicate that 18% of healthcare facilities used AI in 2025. As with other more advanced digital technologies, its adoption varied significantly by facility type. The highest levels of AI use were observed among inpatient facilities with more than 50 beds, where 31% reported using AI, and in SADT, with 29%. The results suggest that the application of these technologies is associated with greater care complexity, a larger volume of clinical data generated, and the presence of more advanced technological infrastructure in these types of facilities. Hospitals with more beds tend to use integrated hospital information systems, diagnostic support solutions, and data analysis platforms, while SADT often operates with data-intensive technologies, such as medical imaging systems and digital laboratories. In both cases, the environment is conducive to the incorporation of AI-based tools.

Among the facilities that used AI, the most adopted tool (by 76%) was generative language models, such as ChatGPT, Gemini, and other AI-based virtual assistants. This result represents an increase compared to 2024, when this proportion was 63%, indicating that this resource is becoming more accessible and has been incorporated into the daily routine of healthcare facilities. These tools can be used for different purposes, such as supporting the preparation of clinical documents, organizing information, consulting technical content, or producing institutional reports and communications. Other frequently used tools were text mining and analysis of written or spoken language (52%), workflow automation (48%), and speech recognition (26%). Image recognition and processing (17%) and machine learning for prediction and data prediction and analysis (15%) were the least used functionalities.

Among inpatient facilities with more than 50 beds, in addition to generative AI (85%), there was a greater presence of tools aimed at automating processes and workflows (56%) and speech recognition for converting spoken language into text (31%), indicating their use to support clinical and administrative routines, such as recording information and clinical documentation (Chart 13). In the case of SADT, in addition to generative AI (73%), process automation tools (50%), and tools for text mining and analysis of written or spoken language (37%) were the most adopted in the analysis of clinical records, reports, and other textual data produced in these services.

CHART 13

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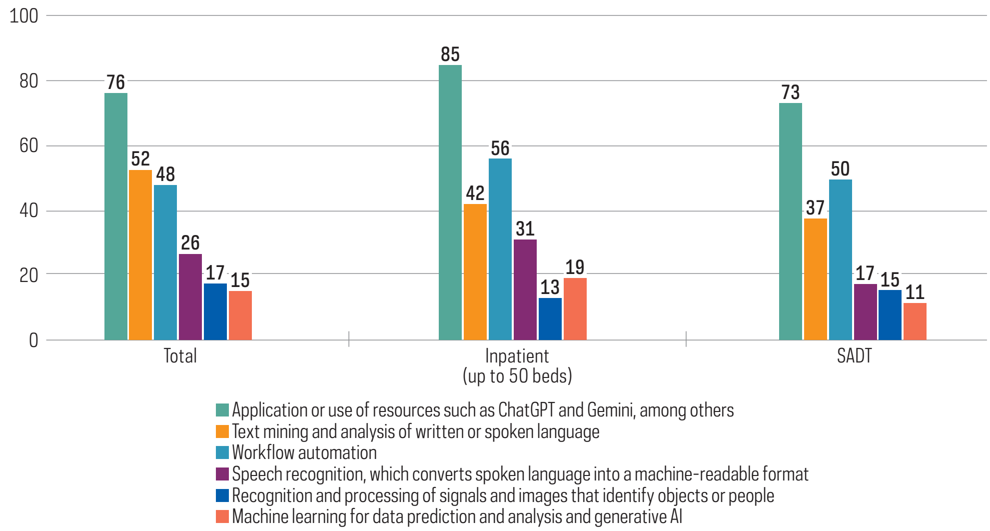
Healthcare facilities that used AI, by type of technology and facility (2025)

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



The survey also identified the use of AI systems geared toward specific applications in the healthcare sector. For all healthcare facilities that used the technology, the main use was for the organization of clinical and administrative processes (45%), a higher proportion than that observed in 2024 (32%). This type of application includes the use of automated systems for information screening, organization of care flows, classification of records, and support for the management of hospital processes. The use of AI to improve treatment efficiency also showed growth, increasing from 29% in 2024 to 32% in 2025, while applications focused on supporting the logistics of health services grew from 27% to 31%. Other relevant applications included using this technology to assist in diagnoses (26%) and to support human resources management or recruitment (27%). However, usage for digital security showed a relative decrease, dropping from 50% to 36%.

Analyzing by type of facility, the use of AI stood out in inpatient facilities with more than 50 beds, where applications were mainly concentrated on functions related to digital security (46%) and the organization of clinical and administrative processes (43%), suggesting that it has been used primarily to support the management and operation of services. In the case of SADT, a similar pattern was observed, with greater emphasis on applications focused on digital security (44%) and organization of clinical and administrative processes (37%), as shown in Chart 14.

CHART 14

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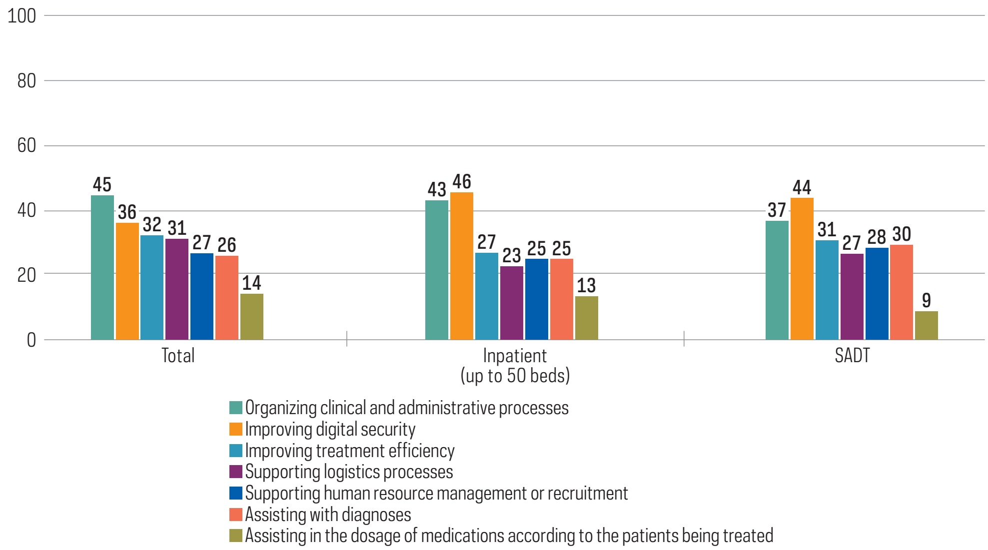
Healthcare facilities that used AI technology, by type of application (2025)

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



Beyond its uses, it is important to understand the main perceived barriers to the adoption of AI in healthcare facilities and to identify whether its low level is more associated with structural and organizational limitations, regulatory issues, or perceptions about the relevance and priority of this technology for healthcare services.

Among inpatient facilities with more than 50 beds, economic and operational factors were given greater weight, with the main obstacle mentioned being that costs seemed very high (63%), followed by the perception that the use of AI is not a priority (56%). Both the difficulties related to data availability or quality and the lack of trained personnel were also mentioned by 51% of facilities, in addition to incompatibility between AI and existing systems (49%). In SADT, the results point to factors related to institutional prioritization as the main obstacles: 64% stated that the use of AI was not a priority and 60% mentioned lack of need or interest. Concerns about data protection and privacy (50%) and the perception that costs are very high (47%) also stood out (Chart 15).

CHART 15

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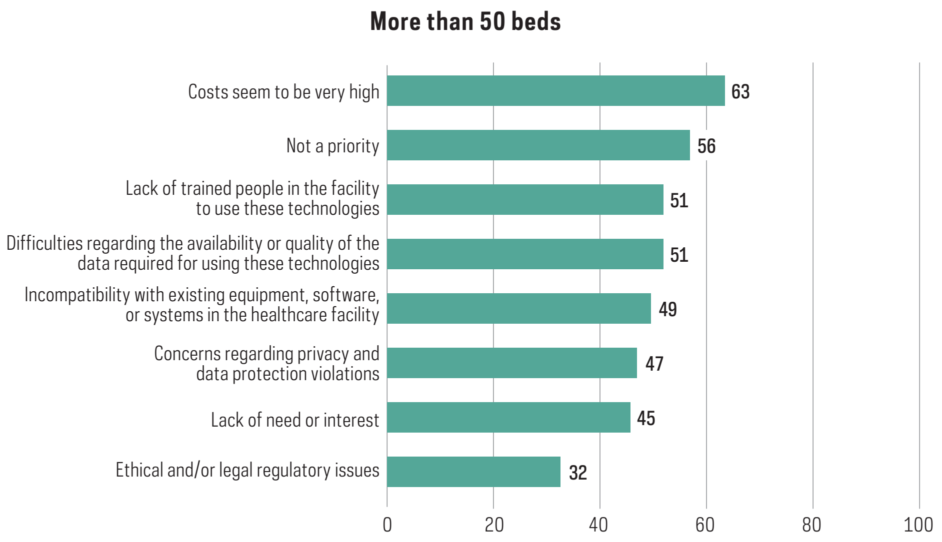
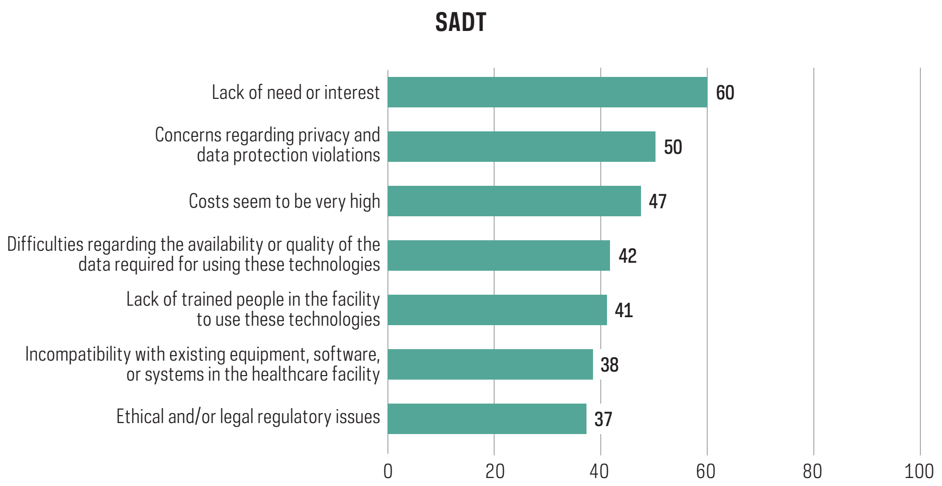
Healthcare facilities by reasons for not using AI, by type of facility (2025)

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





Overall, the results indicate that emerging data-driven technologies are gradually expanding in the Brazilian healthcare sector, although their adoption remains concentrated in larger facilities with greater care complexity. The dissemination of these tools tends to depend not only on the availability of digital infrastructure, but also on factors such as governance and data quality, professional training, and integration between health information systems. The findings suggest that, in addition to technical challenges and the need for qualified human resources, the increased use of AI in the healthcare sector is associated with managers recognizing its strategic value and the existence of organizational and institutional conditions that enable investments and implementation processes.

Final considerations: Agenda for public policies

The results of the ICT in Health 2025 survey indicate that digital transformation in the health sector in Brazil has been gradually advancing in recent years, favored by the expansion of technological infrastructure, the growing adoption of digital systems in healthcare facilities, and the adoption of emerging technologies such as cloud services and AI. National initiatives related to the interoperability of information systems, the expansion of connectivity, and the strengthening of telehealth have contributed to expanding the use of digital technologies in the SUS. These advances point to a process of consolidating the digital health agenda in the country, in which digital technologies are playing an increasingly important role in supporting the management of services, organizing care networks, and expanding the population's access to health care.

However, there are still important areas for further progress in this process, such as implementing actions capable of ensuring adequate technological infrastructure, interoperability between information systems, digital training for professionals, and robust data governance mechanisms. Challenges persist related to the heterogeneity of technological infrastructure among different types of healthcare facilities, the difficulties in integrating information systems—especially in private facilities—and the need to expand the training and capacity-building of professionals responsible for the implementation and management of digital technologies.

Another relevant aspect concerns the territorial and socioeconomic inequalities that characterize the Brazilian health system. The implementation of digital solutions depends on the availability of connectivity, equipment, and institutional capabilities, which can vary significantly across different regions and types of facilities. Public policies aimed at digital inclusion and reducing these inequalities are fundamental to ensuring that digital transformation contributes to strengthening the principles of universality, equity, and comprehensiveness that guide SUS, preventing the expansion of digital technologies from reproducing or amplifying existing inequalities in access to health services.

Furthermore, the advancement of emerging technologies, such as AI, brings new opportunities for the use of data in health care, with applications in areas such as epidemiological surveillance, support for clinical decision-making, and management of health services. However, these innovations also raise challenges related to the transparency of systems, accountability in the use of algorithms, and the protection of sensitive personal data. In this context, strengthening data governance strategies, regulation, and information security become fundamental to ensuring that the use of these technologies occurs ethically, securely, and for the benefit of the population.

Finally, strengthening the capacity for data analysis and use in health systems is a central element for improving the management and planning of healthcare networks. Developing data monitoring and analysis strategies can contribute to improving the efficiency of services, supporting evidence-based decision-making, and strengthening the health system's capacity to respond to current and future healthcare challenges.

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Articles

Artificial Intelligence in health professions education: Impact and responsible use

William Hersh[1]

The overall goal of this review is to discuss the successes and limitations of Artificial Intelligence (AI) in biomedical and health professions education. Biomedical and health professions students can be defined broadly as individuals who work professionally in health care, personal health, public health, and research. This includes clinicians such as physicians, nurses, pharmacists, etc., as well as those who do not provide clinical care, such as administrators, project managers, researchers, educators, and others. Also among these are those who work in biomedical and health informatics, data science, and related areas. This review focuses on generative AI, the area of AI focused on generating output, typically language output based on large language models (LLM) (Teo et al., 2024). The review will describe the successes and limitations of AI, especially those that apply to education.

Usage of generative AI

Since the introduction of ChatGPT, generative AI has been rapidly taken up by a large proportion of people around the world, including biomedical and health professionals, students, consumers, and others. A survey from mid-2024 of teachers, students, and parents found 49%-52% in each group using generative AI frequently, 18%-33% using it occasionally, and less than a quarter of each group stating they had never used it (Impact Research, 2024).

Other surveys have looked at larger populations and noted similar large-scale uptake of generative AI. One analysis from August 2024 found that 39% of working-age adults used generative AI (Bick et al., 2024). It also found that more than 24% of such individuals used it in their work at least once a week, and about 10% used it every day at work. The authors of the survey noted that the adoption of generative AI has been even faster than adoption of personal computers or the Internet.

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Another survey, this one of over 1,000 physicians from the United Kingdom, found that 20% reported using generative AI tools in clinical practice (Blease et al., 2024). Among those who used such tools, 29% reported using them to generate documentation after patient appointments and 28% to develop a differential diagnosis. An additional survey of 2,428 US adults of varying age, geographic location, and race/ethnicity carried out by the Kaiser Family Foundation found that about two-thirds of respondents reported some use or interaction with AI (Presiado et al., 2024). However, use of AI chatbots for health information and advice was much lower than for social media or Internet search (Table 1).

TABLE 1

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Use of sources for health information and advice

Source	Every day	At least once a week	At least once a month	Occasionally	Never
Social media	46	10	4	18	22
Internet search	42	21	9	21	7
AI chatbots	6	7	4	19	63

Source: adapted from Presiato et al. (2024).

Performance of AI in education-related tasks

A large amount of research has been published on the results of AI applied to biomedical and health tasks. Many of these studies have focused on answering questions, especially those on examinations, including medical board tests. Others have expanded to solving clinical cases or carrying out other clinical tasks, although few involve actual users and almost none have been implemented in real-world settings. Nonetheless, these results impact education in that they can carry out tasks used in educational activity, including student practice and assessments.

The following categories of research will be described in this section:

- Medical board examinations.
- Answering clinical questions.
- Solving clinical cases.
- Assessing clinical reasoning.
- Performance in graduate courses in health informatics.

MEDICAL BOARD EXAMINATIONS

One of the most widely used data sets for AI evaluation comes from a set of sample questions from the US Medical Licensing Exam (USMLE) (Jin et al., 2021). This multiple-choice question (MCQ) exam is taken in three steps during the second and fourth years of medical school and then in the first year out of medical school. The dataset, called MedQA, includes 12,723 questions in English (and others in Chinese). An early and highly publicized success of the original ChatGPT was to achieve a score of over 60% on the MedQA dataset using the GPT-3.5 LLM, which would equate to a passing grade (Kung et al., 2023). This level was surpassed by other LLM, including GPT-4 (Nori et al., 2023) and Google's Med-Gemini (Corrado & Barral, 2024). The most recent leader in the "USMLE arms race" is OpenAI's o1 model, scoring 96.0% (Horvitz et al., 2024; Nori et al., 2024), although OpenEvidence claims to have achieved a perfect score on this dataset (OpenEvidence, 2025).

There have also been successes on other US-based medical board exams, such as in the fields of radiology (Adams et al., 2024; Bhayana et al., 2023), neurosurgery (Ali et al., 2023), and clinical informatics (Kumah-Crystal et al., 2023). Furthermore, success on board exams has not been limited to the US. In Israel, the scores of all resident physicians who completed board exams in the specialties of pediatrics, internal medicine, psychiatry, obstetrics/gynecology, and general surgery in 2022 were compared to GPT-3.5 and GPT-4 (Katz et al., 2024). GPT-4 passed the exams in all of the specialties, scoring comparably in internal medicine and general surgery, better in psychiatry, and inferiorly in pediatrics and obstetrics/gynecology.

ANSWERING CLINICAL QUESTIONS

Other research has assessed the ability of AI to answer clinical questions in diverse medical disciplines. One of the most studied applications areas has been cancer. One study assessed ChatGPT output for concordance with National Comprehensive Cancer Network (NCCN) treatment guidelines for breast, prostate, and lung cancer. The study found an overall concordance of 61.9% of the time, with 34.3% of outputs recommending one or more nonconcordant treatments. The study also found that responses were hallucinated, i.e., were not part of any recommended treatment, in 12.5% of outputs (Chen et al., 2023). Another study assessed several different LLM and found varying performance on different categories of oncology questions, with ChatGPT-4 the only LLM to score greater than 50% (Rydzewski et al., 2024).

The success of AI has not been limited to cancer. One study of 284 questions developed by physicians found that ChatGPT-4 had highly accurate and complete answers and performed better than ChatGPT-3.5 (Goodman et al., 2023). Another study looked at ChatGPT-3.5 answering MCQ about human genetics (Duong & Solomon, 2024). ChatGPT-3.5 responses were found to be correct comparably to human answerers (68.2% vs. 66.6% respectively.

There are many other medical question-answering datasets that have been developed and used to compare generative AI systems. One recent analysis used a large number of them to compare the new OpenAI o1 LLM that makes use of a new type of prompting called chain of thought prompting, where prompts to the LLM describe the task iteratively, and found that it surpassed GPT-4 in accuracy by an average of 6.2% and 6.6% respectively across 19 datasets and two newly created complex question-answering scenarios (Xie et al., 2024). However, the study also noted several weaknesses of the LLM, including hallucination, inconsistent multilingual ability, and discrepant metrics for evaluation. We can see from all of these studies that generative AI is very good at answering questions on medical examinations, yet is far from perfect and does suffer from incorrect and/or inconsistent answers.

SOLVING CLINICAL CASES

Additional analyses of AI have gone beyond answering questions to assessing the ability to solve clinical cases. One early line of research used a collection of clinical vignettes that were originally developed in the mid-2010s to assess the performance of clinical symptom-checkers (Semigran et al., 2016). Most systems using them performed poorly at the time, and certainly far worse than physicians, who averaged about 72% accuracy.

One study assessed ChatGPT-3.5 with this dataset for first-pass diagnostic and triage decision accuracy, finding that ChatGPT-3.5 identified illnesses with 75.6% first-pass diagnostic accuracy and 57.8% triage accuracy (Benoit, 2023). This study also found that ChatGPT was useful for generating new vignettes written for those with both high and low health literacy levels. Another study found that ChatGPT-3.5 identified the correct diagnosis in the top three diagnoses for 88% of cases, compared to 54% for lay individuals and 96% for physicians (Levine et al., 2024). ChatGPT-3.5 was also found to triage 71% of cases correctly, similar to lay individuals, with both worse than physicians, who triaged correctly for 91% of the cases.

Some studies have used the clinicopathologic conferences (CPCs) featured in the New England Journal of Medicine (NEJM). These well-known cases are deemed to be challenging and often stump even Harvard Medical School faculty. One study found that GPT-4 provided the correct diagnosis within the differential diagnosis in 64% of the 70 cases assessed and as the top diagnosis in 39% of cases (Kanjee et al., 2023). Another study found GPT-4 to be correct for 57% of 38 cases assessed, which was better than almost all online readers who answered the challenge (Eriksen et al., 2023). A follow-on analysis compared performance for GPT-4 with cases that were newer and older than the September 2021 training date of GPT-4, aiming to control for possible data leakage, i.e., the early cases potentially being in the training data. This analysis found comparable results in newer and older cases.

ASSESSING CLINICAL REASONING

AI has also been studied for the ability to assess clinical reasoning. In one study of clinical reasoning using 20 patient cases, GPT-4 was found to perform comparably to attending physicians and residents in diagnostic accuracy, correct clinical reasoning, and cannot-miss diagnosis inclusion (Cabral et al., 2024). In another pair of studies, physicians were assessed on a set of clinical vignettes developed to assess clinical decision support systems from the 1990s (Bernet et al., 1994). Physicians were randomized to different vignettes to having conventional information resources with or without the addition of GPT-4 and assessed using an instrument to assess diagnostic reasoning (Goh et al., 2024). Physicians using GPT-4 scored comparably to those not using it (76% vs. 73%), although those using ChatGPT-4 showed a trend toward solving cases faster (565 vs. 519 seconds). GPT-4 alone scored much higher at 92%. In a similar randomized vignette study assessing clinical management decisions, physicians scored 6.5% higher using an LLM compared to those using conventional resources, but in this instance, GPT-4 alone did not do better (Goh et al., 2024).

Clinical problem-solving was also assessed in a blinded observational comparative study conducted in the primary care setting in Sweden (Arvidsson et al., 2024). Responses from GPT-4 and real physicians to cases from a family medicine specialist examination were scored by blinded reviewers. In these complex primary care cases, GPT-4 and the follow-on GPT-4o performed worse than average human physicians. Recognizing the need to assess clinical reasoning with more complex dialogues and fewer multiple-choice questions, the Conversational Reasoning Assessment Framework for Testing in Medicine (CRAFT-MD) dataset was developed (Johri et al., 2025). This dataset focuses on natural dialogues, using simulated agents to interact with LLM in a controlled environment. The CRAFT-MD framework was found to show that LLM performed notably worse in conversational settings compared to examination-based evaluations. The authors noted that more realistic testing approaches must be developed before LLM can be safely integrated into clinical workflows and proposed a set of recommendations to align LLM evaluations with real-world clinical practice.

PERFORMANCE IN GRADUATE COURSES IN HEALTH INFORMATICS

Another area where AI success in education has been assessed is in graduate-level health informatics courses. This author carried out an analysis that compared student knowledge-assessment scores with prompting of 6 large-language model (LLM) systems as they would be used by typical students in a large online introductory course in biomedical and health informatics at Oregon Health & Science University (OHSU) (Hersh & Fultz, 2024). This course is taken by graduate, continuing education, and medical students. The state-of-the-art LLM systems were prompted to answer 10 MCQ each from the 10 units of the course along with 33 final exam questions. Scores for 139 students (30 graduate students, 85 continuing education students, and 24 medical students) who took the course in 2023 were compared to the LLM systems. Google's Gemini scored highest across all assessments, but the rest of the LLM did well enough to achieve a passing grade for the course and scored between the 50th and 75th percentiles of students (see Figure 1). The performance of the LLM raised questions about how to assess students in higher education, especially in courses that are knowledge-based and online.

FIGURE 1

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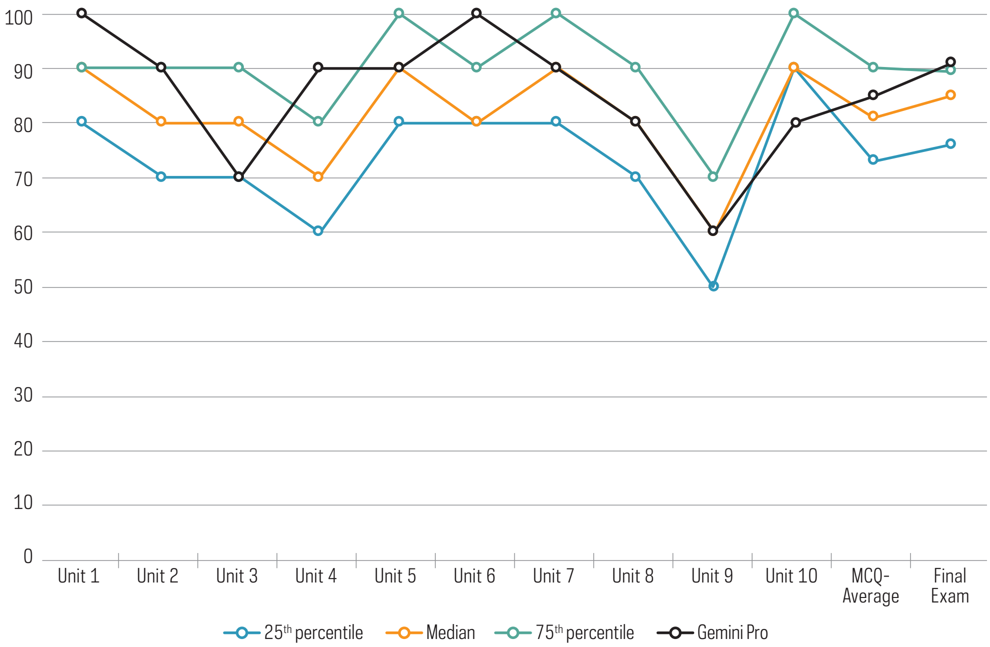
Comparison of student and LLM model scores on health-related assessments



Source: Hersh & Fultz Hollis (2024).

Note: The chart refers to student scores for 25th, 50th (median), and 75th quartile of performance (blue, orange, and green lines, respectively) vs. best-performing LLM, Gemini Pro (black line) in the individual and aggregate unit assessments and the final examination for a large, online introductory biomedical and health informatics course.

An additional study in health informatics looked at the use of GitHub CoPilot in a programming-oriented course (Avramovic et al., 2024). GitHub is a computer code repository system that has been integrated with an OpenAI LLM that aims to assist in the writing of computer code. The system was evaluated in a health informatics programming course for two types of programming problems, one for database queries in structured query language (SQL) and the other for computational tasks using the Python programming language. In general, the generated solutions worked well for simple and straightforward SQL and Python tasks but less well for more complex ones. It was also noted that some solutions were correct but did not take the most efficient approach to programming.

Impact of generative AI on education

AI is clearly having an impact on activities associated with education. This section of the review will describe recommendations for best practices going forward and cover the following topics:

1. Competencies for use of AI.
2. Role in clinical education.
3. Responsible use in clinical education.

COMPETENCIES FOR USE OF AI

Some work has focused on student competencies for AI, mainly focused on use by students who will become practicing clinicians. One well-known set of competencies in clinical informatics was developed a decade ago (Hersh et al., 2014) and was recently updated to include the following AI-related competencies (Hersh, 2023):

- Find, search, and apply knowledge-based information to patient care and other clinical tasks.
- Effectively read from, and write to, EHR for patient care and other clinical activities.
- Use and guide implementation of clinical decision support (CDS).
- Provide care using population health management approaches.
- Protect patient privacy and security.
- Use information technology to improve patient safety.
- Engage in quality measurement selection and improvement.
- Use health information exchange (HIE) to identify and access patient information across clinical settings.
- Engage patients to improve their health and care delivery through personal health records and patient portals.
- Maintain professionalism through use of information technology tools.
- Provide clinical care via telemedicine and refer patients as indicated.
- Apply personalized/precision medicine.
- Participate in practice-based clinical and translational research.
- Use and critique AI applications in clinical care.

Other competency frameworks have been proposed that are more specific to AI. One focuses on the use of AI in primary care, proposing competencies in six domains (Table 1, part 1), while the other focuses on the use of AI-based tools by healthcare professionals more broadly (Table 2, part 2). A more recent competency framework has been developed for medical school faculty who must teach with and about AI (Pylman et al., 2025).

TABLE 2

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Competency frameworks specific to AI

1. AI in primary care (Liaw et al., 2022)	2. AI for health professionals (Russell et al., 2023)
▪ Foundational knowledge – What is this tool? ▪ Critical appraisal – Should I use this tool? ▪ Medical decision-making – When should I use this tool? ▪ Technical use – How do I use this tool? ▪ Patient communication – How should I communicate with patients regarding the use of the tool? ▪ Unintended consequences (cross-cutting) – What are the "side effects" of this tool?	▪ Basic knowledge of AI – Explain what AI is and describe its healthcare applications. ▪ Social and ethical implications of AI – Explain how social, economic, and political systems influence AI-based tools and how these relationships impact justice, equity, and ethics. ▪ AI-enhanced clinical encounters – Carry out AI-enhanced clinical encounters that integrate diverse sources of information in creating patient-centered care plans. ▪ Evidence-based evaluation of AI-based tools – Evaluate the quality, accuracy, safety, contextual appropriateness, and biases of AI-based tools and their underlying datasets in providing care to patients and populations. ▪ Workflow analysis for AI-based tools – Analyze and adapt to changes in teams, roles, responsibilities, and workflows resulting from implementation of AI-based tools. ▪ Practice-based learning and improvement regarding AI-based tools – Participate in continuing professional development and practice-based improvement activities related to use of AI tools in health care.

Source: Adapted from Liaw et al. (2022) and Russell et al. (2023).

ROLE IN CLINICAL EDUCATION

There is an important role for AI in clinical education. One important consideration is that different members of the health professions workforce have different needs. Ng et al. (2023) have developed a matrix of three categories of users and the knowledge and skills required by each:

- Consumers – those who apply AI in their clinical work, e.g., physicians, nurses, pharmacists, and other health professions.

- Translators – those who combine clinical and technical expertise to guide implementation and evaluation of AI, e.g., clinical informatics and digital health specialists.
- Developers – those who build AI models.

There are overlaps among these categories, but all require competence in technical concepts, ethics, validation, and appraisal.

Although most competency frameworks have focused on medical students and physicians, others have been developed for other health professionals. Nursing education leaders have recognized that AI will impact all aspects of nursing practice, education, and administration (Barbosa et al., 2025). There is a recognized need for AI to be integrated into nursing education programs (National League for Nursing, 2025; Sockolow et al., 2025). Additional health professions have recognized the growing role of AI in their practice and the need for its inclusion in education and training, e.g., pharmacy (Wong et al., 2023). Indeed, AI is an important topic for interprofessional practice and is well-suited for interprofessional education (IPE) activities (Stewart et al., 2025).

A number of authors have written about the role of generative AI in clinical education specifically. One narrative review looked at the potential of LLM for medical education, noting potential advantages for students and faculty, but also pointing out challenges (Benitez et al., 2024). This narrative review noted advantages to students, such as more direct access to information, personalizing learning activities, and facilitating development of clinical skills. Potential benefits for faculty and instructors include the development of innovative approaches to pedagogy for complex medical concepts and facilitating student engagement. However, the review also noted a number of challenges, such as leading to academic misconduct, becoming over-reliant on AI, diluting critical thinking skills, concerns about the veracity and reliability of LLM-generated content, and implications for all of these on teaching staff.

Another paper proposed a set of recommendations for medical faculty and their institutions (Boscardin et al., 2023). The authors advocated that educators must increase their knowledge of AI, understand the current landscape for its use in medical practice and education, review strategies for successful AI integration into education, and become stewards of its ethical use. Likewise, institutions should review and revise school policies, creating new policies as needed, regarding use of AI; support faculty development about AI and provide resources for teaching; and offer information-checking tools for originality and plagiarism to faculty.

Safranek et al. (2023) noted a number of use cases for how LLM can be integrated into medical education:

- Practice generating differential diagnoses.
- Streamlining the wide array of study resources to assist with devising a study plan.
- Serving as a simulated patient or medical professor for interactive clinical cases.
- Helping students review multiple-choice questions or generating new questions for additional practice.
- Digesting lecture outlines and generating materials for flash cards.

- Organizing information into tables to help build scaffolding for students to connect new information to previous knowledge.

Other uses for LLM in health professions education that have been proposed include creating checklists for common presentations and generating templates for common clinical scenarios (Bair et al., 2023), presenting potential patient problems to nurses, guiding students through clinical processes (Gosak et al., 2024), and generating radiology board-style MCQs (Mistry et al., 2024).

RESPONSIBLE USE IN EDUCATION

The use of AI for educational tasks has raised issues about its appropriate use and whether some aspects may undermine clinical learning and its assessment (Hersh, 2025). Education leaders inside and outside of health professions have expressed concerns for student use of AI. One early thought leader coined the term "homework apocalypse" to describe its positive and detrimental use by learners (Mollick, 2023).

Others have noted that although AI may reduce cognitive load and increase student efficiency, it may also undermine the information gathering and task execution aspects of cognitive work, including clinical work (Lee et al., 2025). Another study assessed the use of generative AI tools in student essay-writing through both the use of electroencephalogram (EEG) measurement and student recall of essay content (Kosmyna et al., 2025). The results showed a "cognitive debt" in that students using AI had less cortical engagement via EEG and were less able to summarize as well as later recall the contents of their essays.

A related concern in medical education arises from studies showing that use of AI assistance by colonoscopists may lead to their "de-skilling" in performing procedures (Budzyn et al., 2025). This has led to other possible detrimental effects in education, such as "mis-skilling" and "never-skilling" (Abdulnour et al., 2025). Some have noted the need for a reckoning on how we maintain a student-centered focus and the integrity of student assessment, perhaps with a need to redefine "cheating" in education (Gallant & Rettinger, 2025).

Conclusions

AI is having a profound impact on health professionals and their education. It has been rapidly taken up by clinicians, students, and indeed all of society. AI systems have been found to perform as well as human experts in many, but not all, intellectual tasks, including medical board exams, answering clinical questions, solving clinical cases, and applying clinical reasoning, and performing well in academic courses. For many activities, it helps less experienced individuals more than experts, although in other situations it can lead all people astray. However, all students and faculty, in biomedicine and health and beyond, must have a thorough understanding of AI and be competent in its use.

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Clinical staff workload and the need for better integrated electronic health records: A longitudinal study in French hospitals

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In many countries, hospitals are undergoing significant transformations driven by population aging, the rising prevalence of chronic diseases, health system reforms, and budgetary constraints. In activity-based financing healthcare systems, as in France, these changes have resulted in decreased bed capacity, increased hospital admissions, shorter lengths of stay, and greater pressure on human resources, particularly on physicians and nurses (Hadji et al., 2014; Marchandot & Morel, 2025). Such transformations raise critical questions about hospitals' ability to maintain the quality and safety of care while remaining financially efficient.

Although several studies have examined hospital activity trends and the working conditions of physicians and nurses (Aiken et al., 2023; Lui et al., 2018), relatively few have analyzed both dimensions jointly at the national level over an extended period (Maunder, 2023; Musy, 2020; Narymbayeva et al., 2025). Analyzing these dynamics requires longitudinal analyses capable of tracking the joint evolution of hospital activity and clinical staff workload over a prolonged period. Structural differences between the not-for-profit (NFP) and for-profit (FP) sectors—particularly regarding missions, organizational models, and patient care—further justify a comparative analysis (Meier, 2025; Rosenau, 2003). Such distinctions are essential for understanding underlying organizational mechanisms and identifying factors that may influence health system resilience, as highlighted during the COVID-19 pandemic (Ellis et al., 2023; Jeurissen et al., 2021; Yinusa & Faezipour, 2023).

Within this context, this study aims to examine trends in hospital activity and clinical staff workload in France over the period 2012 to 2024. The study also seeks to compare trajectories across the public and private sectors, highlighting differential patterns in the deployment of hospital resources. The overarching goal is to provide a structured understanding of ongoing changes and to contribute to the comprehension of current and future challenges facing the French health system, from both organizational and strategic perspectives. It is considered a prerequisite to evaluate the possible effects of the progressive introduction of information technology (IT) into the existing health systems.

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Material and methods

This longitudinal study analyzed national data from French national registries (Agence Technique de l'Information sur l'Hospitalisation [ATIH], 2025a; Direction de la Recherche, des Études, de l'Évaluation et des Statistiques [DREES], 2025a, 2025b) and reports from international organizations (Organisation for Economic Co-operation and Development [OECD], 2025; WHO Regional Office for Europe [WHO/Europe], 2025). The French hospital financing system is associated with a diagnosis-related group (DRG) coding approach, the *Programme de Médicalisation des Systèmes d'Information* (PMSI), with the transmission of hospital-acquired data to a national agency, the ATIH (ATIH, 2025a; Chevreul et al. 2015). Statistical figures are made available on the DREES ATIH websites.

The results presented in this article concern all hospitals in metropolitan France and the overseas departments. Three health professional categories are considered: senior physicians (SPs), registered nurses (RNs), and assistant nurses (ANs).

French national indicators are provided in Table 1, and hospital-related indicators in Tables 2 to 4 and Charts 1 and 2. Two follow-up periods were selected: the pre-COVID-19 period (2012–2019), and the overall follow-up period (2012–2024).

Hospital indicators concern only the acute care sector (medicine, surgery, and obstetrics) and their associated health staff resources and activities (ATIH, 2025b). Psychiatric care, rehabilitation, long-term care, and home care are not accounted for in this study. Two groups of hospitals are compared: NFP public and private hospitals on one side, and FP hospitals on the other. The professional workforce is defined as the mean yearly number of retributed full-time equivalents (FTEs) for a given period. For each profession and each study period, the professional workload is calculated as the ratio of patient stays to the corresponding profession's workforce, adjusting for all causes of absenteeism.

To simplify the presentation of results, indicators in tables are aggregated by two-year intervals, except for the 2020 COVID-19 pandemic year. The significance of trends is calculated by regression analysis for quantitative variables and by Armitage's Chi2 for percentages (Armitage, 2002) for both the pre-COVID (2012–2019) and the complete follow-up (2012–2024) periods.

Results

HEALTHCARE FIGURES IN FRANCE

Between 2012 and 2024, the French population grew from 65.4 to 68.5 million (+4.77%), while the number of adults ≥65 years increased from 11.4 to 14.8 million (+30.4%) (Table 1). In contrast, the number of individuals <15 years fell by 5.2%, and those 15–64 years increased by 0.72% (Table 1).

Hospital beds decreased from 414.8 to 369.4 thousand between 2012 and 2024 (–11.85%). Bed density dropped from 6.34 to 5.34 beds per 1,000 population (–15.9%, p<0.001), with sharper reductions in the NFP sector (–16.7%) than in the FP one (–13.2%). As a result, the ratio of the ≥65-year-old population to available beds increased by 47.9% over the entire period.

HOSPITAL FIGURES IN FRANCE

Between 2012 and 2024, acute care beds declined from 255.2 to 226.8 thousand (–11.1%). The number of inpatient beds decreased from 223.1 to 186.3 thousand (–16.5%) while day-care beds increased from 32.2 to 40.6 thousand (+26.2%).

Over the same period, the hospital workforce in FTEs grew from 1.13 to 1.25 million (+9.9%, p<0.001). Senior physicians (SPs) increased from 92.7 to 109.4 thousand (+18.1% p<0.001. Registered nurses (RNs) rose from 344.6 to 366.7 thousand (+6.4%, p<0.001), and assistant nurses (ANs) rose by +1.7%. The RN/SP ratio therefore fell significantly from 3.72 to 3.35 (–9.9%), and the AN/RN ratio from 0.94 to 0.90 (-4.4%).

Between 2012 and 2024, the overall number of admissions rose from 18.6 to 21.3 million (+14.7%). The inpatient admissions fell from 12.93 to 11.84 million (–8.5%), while day-care stays increased from 5.65 to 9.48 million (+67.8%). Surgical stays declined from 5.57 to 3.84 million (–32.7%). Mean length of inpatient stays shortened from 6.1 to 5.6 days (–8.5%, p<0.001).

Absenteeism-adjusted senior SP staff load increased by 8.8%, while the RN workload rose by 8.9% and the AN workload by 9.4% (Table 2 and Chart 1).

TABLE 1

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Healthcare figures in France

Years §	2012-2013	2014-2015	2016-2017	2018-2019	Δ% 2012-2019	2020	2021-2022	2023-2024	Δ% 2012-2024
French population in millions ◇	65.57	66.39	66.79	67.24	2.98 %	67.57	68.02	68.43	4.77%
<15 yrs – no. (%)	12.18 (18.6)	12.32 (18.5)	12.22 (18.3)	12.10 (18.0)	-0.71%	12.00 (17.8)	11.86 (17.4)	11.60 (16.9)	-5.18%
15- 64 yrs – no. (%)	41.87 (63.9)	41.85 (63.0)	41.69 (62.4)	41.67 (62.0)	-0.52%	41.72 (61.7)	41.95 (61.7)	42.16 (61.6)	0.72%
⩾ 65 yrs – no. (%)	11.52 (17.6)	12.22 (18.4)	12.87 (19.3)	13.46 (20.0)	19.85%	13.86 (20.5)	14.2 (20.9)	14.67 (21.4)	30.37%
Male sex in millions – no. (%)	31.75 (48.43)	32.14 (48.41)	32.31 (48.37)	32.52 (48.37)	2.88%	32.7 (48.39)	32.94 (48.44)	33.18 (48.49)	4.92%
Mortality rate (/1000 population)	8.69	8.68	8.98	9.09	4.50%	9.90	9.83	9.39	8.20%
Healthcare beds in thousands – ǂ	413.8	411.7	409.3	405.9	-5.82 %	401.6	397.3	393.0	-11.85%
Not-for-profit – no. (%)	316.3 (76.3)	314.9 (76.2)	313.21 (75.9)	310.58 (75.8)	-6.36%	306.76 (75.8)	302.74 (75.6)	299.55 (75.5)	-12.72%
For-profit private – no. (%)	98.55 (23.7)	97.89 (23.8)	97.44 (24.1)	97.3 (24.2)	-4.10%	97.15 (24.2)	96.51 (24.4)	95.76 (24.5)	-9.05%
Bed density (no. beds/1,000 population)	6.31	6.16	6.01	5.85	-8.54%	5.71	5.55	5.37	-15.86%
⩾ 65 yrs population/ healthcare beds	27.85	29.87	32.06	34.25	27.25%	35.9	37.65	39.92	47.89%

Note: § = Mean yearly numbers (no.) and percentages for each period; *p* = trends p values using regressions for quantitative values and Armitage chi2 for percentages; ◊ = Source: OECD (2025); All beds including emergency, psychiatry, long-term care, rehabilitation, and home-based care.

TABLE 2

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Healthcare figures in French hospitals

Years §	2012-2013	2014-2015	2016-2017	2018-2019	Δ% 2012-2019 †	2020	2021-2022	2023-2024	Δ% 2012-2024 †
Acute care beds in thousands - no. ◇	254.0	246.7	240.8	236.4	-7.7%	232.7	226.6	226.3	-11.1%
Inpatient beds - no. (%)	221.5 (87.2)	215.0 (87.1)	208.3 (86.5)	202.7 (85.8)	-9.6%	198.1 (85.1)	190.5 (84.1)	186.6 (82.5)	-16.5%
Day-care beds - no. (%)	32.5 (12.8)	31.7 (12.8)	32.6 (13.5)	33.6 (14.2)	5.1%	34.6 (14.9)	36.0 (15.9)	39.7 (17.5)	26.2%
Health professionals in thousands - no. ǂ	1.086.5	1.110.0	1.129.5	1.146.0	6.4%	1.190.0	1.221.5	1.240.0	14.8%
Senior physicians (SPs) - no. (%)	90.7 (8.0)	93.7 (8.2)	96.5 (8.3)	100.8 (8.6)	13.8%	100.0 (8.7)	99.2 (8.3)	96.8 (7.8)	7.1%
Registered nurses (RNs) - no. (%)	211.3 (18.6)	216.3 (18.8)	221.3 (19.1)	228.0 (19.5)	9.5%	228.5 (19.7)	226.3 (19.0)	225.0 (18.2)	7.6%
Assistant nurses (ANs) - no. (%)	155.5 (13.7)	161.5 (14.1)	167.5 (14.5)	175.0 (15.0)	14.9%	174.0 (15.0)	171.0 (14.4)	167.8 (13.6)	8.4%
RN/SP staff ratio	2.33	2.31	2.29	2.26	-3.7%	2.26	2.28	2.32	0.47%
AN/RN staff ratio	0.74	0.75	0.76	0.77	4.9%	0.76	0.76	0.75	0.76%
Mean yearly admissions in millions	18.64	18.55	19.09	19.34	4.7%	17.35	19.15	20.82	14.7%
Inpatient care stays - no. (%)	12.88 (69.1)	12.48 (67.3)	12.39 (64.9)	12.24 (63.3)	-5.6%	11.1 (64.0)	11.28 (58.9)	11.66 (56.0)	-8.5%
Day-care stays - no. (%)	5.76 (30.9)	6.07 (32.7)	6.70 (35.1)	7.10 (36.7)	28.3%	6.25 (36.0)	7.87 (41.1)	9.16 (44.0)	67.8%
Surgical care stays - no. (%)	5.48 (29.4)	5.04 (27.2)	4.71 (24.7)	4.39 (22.7)	-23.4%	3.77 (21.7)	3.85 (19.9)	3.78 (21.7)	-32.1%
Mean length of stay in days	6.07	6.12	6.00	5.90	-3.3%	6.25	5.93	5.66	-8.5%

CONTINUES ▶

▸ CONCLUSION

Years §	2012-2013	2014-2015	2016-2017	2018-2019	Δ% 2012-2019 †	2020	2021-2022	2023-2024	Δ% 2012-2024 †
Staff load (Stays/FTE)									
SP staff load ∂	211.4	204.1	204.6	199.1	-7.0%	180.0	200.6	224.7	8.8%
RN staff load ∂	98.3	96.1	97.2	96.4	-2.2%	86.6	95.3	104.3	7.9%
AN staff load ∂	129.7	124.9	124.4	121.6	-6.9%	110.2	127.6	139.1	9.4%

Note: § = Mean yearly numbers (no.) and percentages for each period; † = Trends within the 2012–2019 and 2012–2024 periods; ◊ = Acute care beds (Source: DREES, 2025a); ǂ FTE = Full Time Equivalents (Source: ATIH, 2025a; DREES, 2025a); SPs = Senior physicians; RNs = Registered nurses; ANs = Assistant nurses; ∂ = Absenteeism-adjusted staff loads (in number of stays" days/number of FTE).

CHART 1

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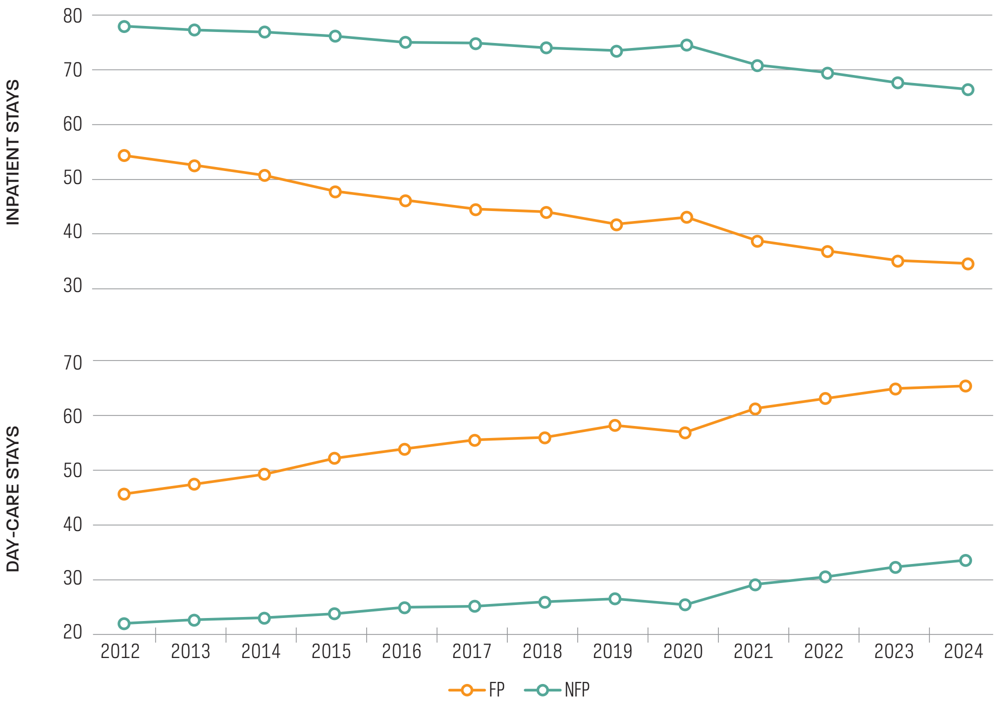
Trends in hospital activity, France (2012–2024)



DIFFERENTIATED TRENDS IN THE NOT-FOR-PROFIT AND FOR-PROFIT HOSPITALS

Tables 3 and 4 and Charts 1 and 2 allow comparison of trends in the NFP and FP sectors across the pre-COVID (2012–2019) and overall (2012–2024) periods. Between 2012 and 2024, acute care bed capacity decreased by 11.2%, but the decline was more pronounced in the FP sector (-20.7%) than in the NFP sector (-7.9%). Significant changes concern the reduction of inpatient beds in the FP sector (-30.5%) and the increase of day-care beds in the NFP sector (+27.2%).

Overall, the increase in hospital staffing between 2012 and 2024 was higher in FP hospitals (+12.5%) than in NFP hospitals (+9.5%). Significant differences included a higher increase in the SP workforce in the NFP sector than in the FP sector (18.3% vs. 3.3%) and a lower increase in the RN workforce (+5.7% vs. 10.9%). The increase in the AN workforce was low in both sectors (+1.7%), lagging behind the simultaneous population increase in France (+4.8%). As a consequence of these variations, the RN/SP ratio decrease was higher in the NFP sector than the FP sector (-10.7% vs. -5.4%) and the AN/RN ratio lower (-2.0% vs. 8.3%), both $p<0.001$.

Mean yearly admissions increased in both sectors, with a more pronounced increase in the NFP sector than the FP sector (+16.7% vs. +11.0%). Significant differences concern the decline in inpatient stays in the FP sector (-29.3%) and the increase in day-care admissions in the NFP sector (+77.9%). The decline in overall surgical admissions was greater in the FP sector than in the NFP sector (-44.6% vs. -21.1%). The decline in inpatient length of stay was higher in the NFP sector than in the FP sector (-8.4 vs. -1.8 %), with a near convergence around 5.5 days in 2024 (5.71 vs. 5.47).

The increase in workload for the three health professions analyzed was higher in the NFP and FP sectors, but the most impressive difference concerns RN workload (+11.5% vs. +0.7%) (Chart 2).

EFFECT OF THE COVID-19 PANDEMIC

Analysis of the tables provides a first clue about the short-term and intermediate effects of the COVID-19 pandemic on several indicators of hospital activity, staff load, and outcome. Despite a regular increase in mortality in France during the pre-COVID period, the 2020 mortality rate (+0.79‰ between 2020 and 2019) appears to persist, albeit at a lower level, in the 2021–2022 period (+0.72‰).

Compared with 2019, 2020 was associated with an 11.7% drop in total admissions and a 6.1% increase in inpatient stay length. The return to previous tendency values was only effective during the 2023-2024 period. Changes in the length of stay were higher in the NFP hospitals (+9.5%) than in the FP hospitals (+7.5%). The reduction in surgical stays was lower in NFP hospitals than in FP hospitals.

CHART 2

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Trends in hospital staff load, France (2012–2024)

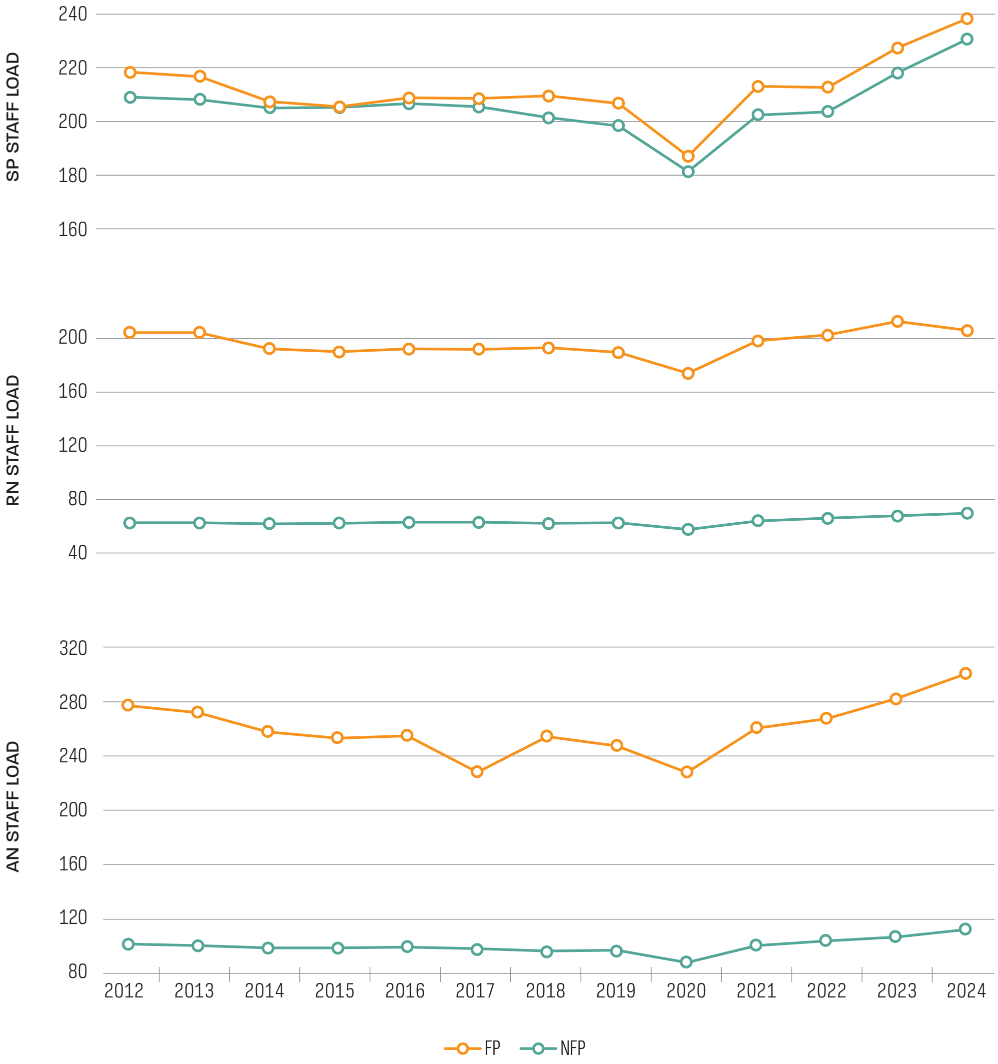

TABLE 3

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Activity and health professional workload in not-for-profit hospitals

Years §	2012-2013	2014-2015	2016-2017	2018-2019	Δ% 2012-2019	2020	2021-2022	2023-2024	Δ% 2012-2024
Acute care beds in thousands - no. ◇	187.3	183.5	179.3	177.2	-5.8%	175.6	173.4	172.5	-7.9%
Inpatient care beds - no. (%)	167.8 (89.6)	164.4 (89.5)	159.6 (89.0)	156.8 (88.5)	-7.3%	154.6 (88.0)	151.4 (87.3)	148.5 (86.1)	-12.0%
Day care beds - no. (%)	19.5 (10.4)	19.2 (10.5)	19.7 (11.0)	20.4 (11.5)	6.7%	21.0 (12.0)	22.0 (12.7)	24.1 (13.9)	27.2%
Health professionals in thousands - no. ǂ	875.3	893.8	908.3	920.0	6.0%	955.0	979.0	992.0	14.0%
Senior physicians (SPs) - no. (%)	59.5 (6.8)	61.4 (6.9)	63.3 (7.0)	66.3 (7.2)	14.2%	66.5 (7.0)	65.2 (6.7)	63.6 (6.4)	7.5%
Registered nurses (RNs) - no. (%)	211.3 (24.1)	216.3 (24.2)	221.3 (24.4)	228.0 (24.8)	9.5%	228.5 (23.9)	226.3 (23.1)	225.0 (22.7)	7.6%
Assistant nurses (ANs) - no. (%)	129.3 (14.8)	134.3 (15.0)	139.3 (15.3)	145.5 (15.8)	14.8%	144.5 (15.1)	142.3 (14.5)	140 (14.1)	9.0%
RN/SP staff ratio	3.55	3.52	3.50	3.44	-4.1%	3.44	3.47	3.54	0.15%
AN/RN staff ratio	0.61	0.62	0.63	0.64	4.9%	0.63	0.63	0.62	1.3%
Mean yearly admissions in millions - no.	12.06	12.22	12.60	12.77	7.3%	11.50	12.73	13.66	16.7%
Inpatient care stays - no. (%)	9.36 (77.7)	9.35 (76.6)	9.45 (75.0)	9.42 (73.8)	1.1%	8.57 (74.6)	8.94 (70.2)	9.16 (67.1)	-0.52%
Day-care stays - no. (%)	2.69 (22.3)	2.86 (23.4)	3.16 (25.0)	3.35 (26.2)	29.4%	2.93 (25.4)	3.80 (29.8)	4.50 (32.9)	77.9%
Surgical care stays - no. (%)	3.17 (26.3)	3.04 (24.9)	2.9 (23.0)	2.75 (21.5)	-14.6%	2.41 (20.9)	2.53 (19.4)	2.52 (18.4)	-21.1%
Length of stay in days - Mean	6.30	6.23	6.02	5.91	-7.5%	6.27	5.93	5.71	-11.1%

CONTINUES ▶

▶ CONCLUSION

Years §	2012-2013	2014-2015	2016-2017	2018-2019	Δ% 2012-2019	2020	2021-2022	2023-2024	Δ% 2012-2024
Staff load (Stays/ETP)									
SP staff load ∂	208.6	205.1	206.0	199.9	-5.1%	181.3	203.3	224.4	10.3%
RN staff load ∂	62.5	62.1	62.9	62.3	0.2%	57.5	64.9	68.6	11.5%
AN staff load ∂	101.0	98.9	98.8	96.6	-4.5%	87.9	102.0	109.3	10.7%

Note: § = Mean yearly numbers (no.) and percentages for each period; † = Trends within the 2012–2019 and 2012–2024 periods; ◊ = Acute care beds (Source: DREES, 2025a); ǂ FTE = Full Time Equivalents (Source: ATIH, 2025a; DREES, 2025a); SPs = Senior physicians; RNs = Registered nurses; ANs = Assistant nurses; ∂ = Absenteeism-adjusted staff loads (in number of stays' days/number of FTE).

TABLE 4

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Activity and health professional workload in for-profit hospitals

Years §	2012-2013	2014-2015	2016-2017	2018-2019	Δ% 2012-2019	2020	2021-2022	2023-2024	Δ% 2012-2024
Acute care beds in thousands - no. ◊	67.0	63.2	61.6	59.2	-13.7%	57.1	56.25	53.8	-20.7%
Inpatient care beds - no. (%)	53.7 (80.2)	50.6 (80.2)	48.7 (79.0)	46.0 (77.7)	-16.7%	43.5 (76.2)	41.8 (74.3)	38.2 (71.0)	-30.5%
Day care beds - no. (%)	13.3 (19.8)	12.5 (19.8)	12.9 (21.0)	13.2 (22.3)	-1.6%	13.6 (23.8)	14.5 (25.7)	15.6 (29.0)	19.3%
Health professionals in thousands - no. ǂ	211.3	216.3	221.3	226.0	8.1%	235.0	242.5	248	18.1%
Senior physicians (SPs) - no. (%)	31.1 (14.7)	31.7 (14.6)	32.1 (14.5)	32.8 (14.5)	6.5%	32.8 (14.0)	32.5 (13.4)	32.1 (12.9)	3.3%
Registered nurses (RNs) - no. (%)	35.0 (16.6.6)	36.3 (16.8)	37.3 (16.8)	38.5 (17.0)	11.4%	38.5 (16.4)	37.8 (15.6)	38.5 (15.5)	14.3%
Assistant nurses (ANs) - no. (%)	26.3 (12.4)	27.3 (12.6)	28.3 (12.8)	29.5 (13.1)	15.4%	29.5 (12.6)	28.8 (11.9)	27.8 (11.2)	5.8%
RN/SP staff ratio	1.13	1.15	1.16	1.18	-0.40%	1.17	1.16	1.20	-5.4%
AN/RN staff ratio	0.77	0.76	0.72	0.77	-8.2%	0.77	0.76	0.72	-8.3%

CONTINUES ▶

▸ CONCLUSION

Years §	2012-2013	2014-2015	2016-2017	2018-2019	Δ% 2012-2019	2020	2021-2022	2023-2024	Δ% 2012-2024
Mean yearly admissions in millions - no.	6.58	6.34	6.48	6.57	-0.20%	5.85	6.66	7.16	11.0%
Inpatient care stays - no. (%)	3.52 (53.5)	3.12 (49.3)	2.94 (45.3)	2.82 (42.9)	-23.2%	2.52 (43.1)	2.52 (37.8)	2.5 (34.9)	-29.3%
Day-care stays - no. (%)	3.06 (46.5)	3.21 (50.7)	3.54 (54.7)	3.75 (57.1)	27.3%	3.33 (56.9)	4.14 (62.2)	4.66 (65.1)	59.0%
Surgical care stays - no. (%)	2.30 (35)	2.00 (31.6)	1.80 (27.8)	1.63 (24.9)	-33.6%	1.37 (23.3)	1.35 (20.3)	1.31 (18.4)	-44.6%
Length of inpatient stays in days - Mean	5.46	5.79	5.95	5.86	10.0%	6.16	5.90	5.47	-1.8%
Staff load (Stays/ETP)									
SP staff load ∂	217.6	206.4	208.7	208.1	-5.3%	187.0	213.7	232.9	9.2%
RN staff load ∂	204.5	191.2	192.1	191.4	-7.2%	174.1	200.3	209.3	0.74%
AN staff load ∂	274.2	255.4	240.4	250.7	-10.6%	227.7	263.8	291.0	8.5%

Note: § = Mean yearly numbers (no.) and percentages for each period; † = Trends within the 2012–2019 and 2012–2024 periods; ◊ = Acute care beds (Source: DREES, 2025a); ǂ FTE = Full Time Equivalents (Source: ATIH, 2025a; DREES, 2025a); SPs = Senior physicians; RNs = Registered nurses; AN s= Assistant nurses; ∂ = Absenteeism-adjusted staff loads (in number of stays" days/number of FTE).

Discussion

HOSPITAL RESOURCES TRENDS

This longitudinal study, covering the period 2012–2024, highlights the structural transformations of the French hospital system in the context of general demographic aging and more specific health financing and budgetary constraints. The continuous decline in the number of inpatient beds, with different adaptations in the NFP and FP sectors, is not particular to the French system but part of a global strategy to develop day-care and outpatient care and modernize hospital services (DREES, 2025b; Or et al., 2015). However, several longitudinal analyses have shown that the pace of downsizing has exceeded the adaptation of alternative care arrangements, leaving elderly, multimorbid, and socially vulnerable patients at heightened risk of unplanned hospitalizations and emergency department visits. In other words, France has faced a cumulative dynamic in which declining hospital capacity and rapid population aging have intensified structural pressures, which the COVID-19 pandemic revealed and accelerated (Lefrant, 2022). After 2020, the return to the reduced capacity amid persistently high demand further intensified tensions in acute care hospitals.

The comparative analysis of hospital sectors highlights contrasting dynamics. The NFP hospitals have emerged as the primary buffer for growing demand, absorbing a disproportionate share of complex patients, at the cost of sustained workload intensification for healthcare teams. Despite a more moderate reduction in bed numbers than in the private sector, public hospitals have experienced continuous growth in admissions and accelerated patient turnover, particularly after 2020. Conversely, the FP hospitals have pursued a stronger orientation toward outpatient care and shorter stays, raising challenges for continuity and coordination of care, especially for patients requiring long-term follow-up.

STAFFING AND WORKLOAD TRENDS

Two significant findings of this study are an increasing workforce and a constant increase in staff workload during the 13-year follow-up period. These trends apply to all three professional categories analyzed: SPs, RNs, and ANs. The increased caregiver workforce is driven by ongoing advances in technology and therapeutic procedures, increasing case complexity, and epidemiologic crises. It appears inferior to the 30.7% increase in the ≥65-year-old high-demand population.

The decline in the RN/SP ratio and the increase in the AN/SP ratio observed during the pre-COVID period are probably markers of excessive pressure on the nursing staff. International comparisons have shown that France's nurse-to-physician ratios have declined more sharply than those of several European countries, intensifying nursing workload and undermining resilience (OECD, 2023; World Health Organization [WHO], 2025). Nursing workforce imbalance is particularly problematic, as nurses occupy a central role in clinical monitoring, care coordination, and complication prevention. Observations in the early 2000s showed that relative nursing staff undersizing is associated with higher rates of adverse events, hospital mortality, and professional burnout (Aiken et al., 2002; Needleman et al., 2002). They gave rise to numerous research studies, literature reviews, and standardized lists of quality and safety indicators (AHRQ, 2025), as well as recommendations on optimal nursing workforce (Aiken et al., 2023; Yinusa & Faezipour, 2023). The COVID-19 pandemic highlighted the crucial role of nurses and the need for rapid adjustment in France, as partially observed in this study. Table 5 summarizes the main issues associated with a too-high nursing workload, including ICD-related codes and AHRQ quality and safety indicators (Southern et al., 2017).

HEALTHCARE ORGANIZATION ISSUES AND THE CRITICAL ROLE OF THE ELECTRONIC HEALTH RECORD (EHR)

Despite strong evidence in the scientific literature of a statistical association between nursing workload and safety issues, this article also shows a strong association between the RN workload and both the SP and AN workloads. It suggests that the relationships could be more complex than currently described and that the cofounding factors selected in the association studies linking the safety issues described in Table 5 should include all caregiver categories, namely SP and AN.

TABLE 5

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Possibly avoidable complications

Possibly avoidable complications	ICD-10 †	Related AHRQ quality indicators ◊
Hospital-acquired infections		
Sepsis	A40, A41, A49, R572, R650, R651, T814	PSI 13, PDI 10, PSI 12
Urinary tract infection (UTI)	N300, N390, N342, N309, N10, N12, T835	PQI 12, PDI 18
Vascular access infection (VAI)	T802, T857	PSI 07
Thromboembolic accident	I260, I29, I80, I828, I829	PSI 12
Pressure ulcer	L890, L891, L892, L893, L899	PSI 03
In-hospital falls		
Fall with injury	W01, W05, W06, W07, W08, W10, W18,	PSI 90
Fall with fracture	W19S22*, S32*, S42*, S52*, S72*	
Adverse effects of drugs	T80*, T887, Y4*, Y5*	PSI 90
Post-operative complication		
Respiratory failure	J80, J951, J952, J953, J954, J958, J960	PSI 06, PSI 11, PDI 09
Hemorrhage or hematoma	T810	PDI 08
Acute renal failure	N17	
Osteoarticular prosthesis infection	T845, T847	-
Wound dehiscence	T813	PSI 14

Note: † ICD-10 = International Classification of Diseases, 10th revision; ◊ AHRQ = Agency for Healthcare Research and Quality (AHRQ, 2025); PSI = Patient Safety Indicators; PDI = Prevention/Disease Indicators; PQI = Patient Quality Indicators.

Another critical dimension is the quality of clinical documentation. Better traceability of care and accessible clinical information are consistently associated with reductions in avoidable complications, early rehospitalizations, and hospital mortality. In systems marked by fragmented care pathways and shorter lengths of stay, health records play a pivotal role in preventing adverse events, particularly among elderly and multimorbid patients. These records highlight clinical observations, anticipate risks, and support continuity of care beyond hospitalization (Luna-Aleixos et al., 2024; WHO, 2025). International evidence reinforces this association. For example, the 2023 OECD *Health at a Glance* report showed that countries with higher nurse-to-patient ratios and robust electronic documentation systems reported lower rates of hospital-acquired complications and readmissions (OECD, 2023).

In a context of faster patient flows and shorter hospital stays, the workload of nurses and physicians extends well beyond direct clinical acts. It increasingly encompasses coordination activities, information transfer, care planning, and the management of transitions between sectors and institutions. Structured, standardized, and comprehensive EHRs shared across professions facilitate continuity of care, support clinical decision-making, and help reduce cognitive load, errors, and omissions among caregivers. Conversely, insufficient or poor-quality documentation amplifies workload, increasing the risk of avoidable complications and adverse events, particularly among elderly and multimorbid patients (Shin, 2019; Twigg et al., 2021). A shared EHR approach implies strict collaboration among the different professions when registering/coding the morbidity conditions present at admission and those observed later, and in the long run, the unification of the current professional-specific terminologies. The long-term objective is to unify the current siloed medical and nursing records into a single, integrated information system. This allows better delineation between what belongs to the patient's initial state and events/complications that could be partially or fully avoided through improved EHR integration and coordinated care.

From the extensive list of indicators described in the literature, the main challenge remains selecting a limited set that can be derived from local health information systems and data warehouses, aggregated across multiple analytical dimensions, and easily interpreted by the different stakeholders. The one-year granularity with yearly indicators selected here was considered justified for a 13-year longitudinal study. A finer granularity would have been helpful for explicitly capturing seasonal variations or epidemic events in terms of resources, activities, and outcome trends. Workforce density in the acute care hospital environment should be considered alongside density indicators in the primary and tertiary healthcare sectors. The professional stay-based workload indicator used here should be compared with other commonly used indicators, such as professional-to-patient ratios or professional-to-patient days ratios. But an endless list of indicators remains an easy excuse for making national and international comparisons impossible to build and for avoiding the shared goal of better health for all.

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Pathways to building smart, paperless hospitals in the Brazilian Unified Health System: The EBSERH experience

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The construction of smart hospitals within the Brazilian Unified Health System (SUS) represents a strategic challenge for the future of public hospital management in Brazil. The large-scale incorporation of digital technologies promises gains in patient safety and autonomy, and improved efficiency in resource allocation (Jovy-Klein et al., 2024). However, this transition requires more than technical innovation: It demands solutions that are simultaneously scalable, financially viable, and sustainable, especially given the well-known budgetary constraints of the public sector (Kwon, 2022).

The objective of this article is to discuss pathways for building smart hospitals that, among other functionalities, seek to progressively eliminate or drastically reduce the use of paper documents within SUS, based on an analysis of the experience of Brazilian university hospitals managed by the Brazilian Company of Hospital Services (EBSERH), a state-owned company linked to the Ministry of Education (MEC) that is responsible for managing 45 federal university hospitals (HUF) that allocate 100% of their healthcare services to the SUS.

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EBSERH is the fourth largest state-owned company in the country, with a workforce of over 87,000 professionals, 8,500 residents, and 55,000 undergraduate students. With a capacity of more than 9,000 beds, the university hospitals of the EBSERH Network perform 6.5 million consultations and 200,000 surgeries annually.

The Pan American Health Organization (PAHO, n.d.) proposes an integrated approach to the concept of smart hospitals, structured around three complementary pillars.

The first axis, called the *Safe Component,* emphasizes the robustness of the hospital's overall infrastructure and its ability to maintain operations in adverse situations. This includes requirements such as solid roofs and foundations, secure storage of critical supplies, backup power and water, efficient drainage systems, accessibility, disaster management plans, and preventive maintenance.

The second axis, *Green*, is ecological in nature and deals with the environmental sustainability of hospital units. It involves practices such as water efficiency, proper waste management, rainwater harvesting, use of renewable energy, reduction of pollutants, efficient climate control, and improvement of indoor air quality.

Finally, the third axis, *Smart*, which is the subject of this article, is related to the adoption of digital technologies and automation to improve management, enhance patient care, and expand the responsiveness of services. In healthcare settings, this represents the complete computerization of the patient's journey, with the structured recording of clinical information in real time, from admission to hospital discharge. It involves the adoption of interoperable electronic health records, secure digital prescribing, clinical decision support systems based on protocols and data, and the possibility of integration with telehealth platforms, expanding access to specialists and diagnostic support services in remote regions. Emerging technologies such as the Internet of Things (IoT) enable continuous monitoring of vital signs, equipment location, and surveillance of critical environments, while Artificial Intelligence (AI) tools can be applied to interpret tests and support clinical decision-making (Shortliffe & Cimino, 2014).

In the administrative dimension, this includes everything from inventory control and traceability of supplies to contract management, work schedules, bed allocation, and billing, using integrated systems capable of automating routines, reducing rework, and ensuring greater accuracy in records (Shortliffe & Cimino, 2014). The adoption of digital technologies allows, for example, that medicine orders can be automatic linked too a system control to check decrease in stock, the real-time monitoring of bed occupancy, or the generation of data directly usable in billing and planning systems related to healthcare production. The use of management dashboards, business intelligence (BI) systems, and predictive algorithms improves decision-making and anticipates operational needs, such as replenishing critical supplies or resizing teams.

In the current context of SUS, the use of paper in smart hospitals should not be completely abolished, as not all patients have access to smartphones or other digital technologies to access their prescriptions, exams, or other clinical documents. However, its use should gradually become an exception, and hospitals should have 100% digital workflows for all patients who can interact using electronic means, ensuring that registration, processing, and access to information are preferably done in digital format.

The EBSERH Network houses the largest public electronic hospital record system in SUS, the Management Application for University Hospitals (AGHU). This is a system widely used by all workers and managers of the university hospitals, with approximately 4 million accesses per month.

AGHU, whose original name was Hospital Management Application (AGH), was created in 2009 through a partnership between the Hospital de Clínicas de Porto Alegre (HCPA) and MEC, with the goal of developing a robust public hospital information system aligned with the needs of federal university hospitals. Initially developed with a focus on computerizing the healthcare and administrative processes of HCPA, the system was progressively adopted by the units of the EBSERH Network starting in 2013, shortly after the creation of the public company and the incorporation of federal university hospitals into its management.

In 2017, EBSERH assumed full responsibility for the maintenance and development of AGHU and has since expanded its functional scope and consolidated the system's implementation in the vast majority of university hospitals linked to MEC. AGHU enables extensive digitization of key clinical and administrative processes in hospitals, such as clinical progress notes for inpatients, outpatient care records, medical prescriptions, pharmaceutical care, inventory control, and more.

In 2023, AGHU became available free of charge to hospitals that provide services to SUS, through a Technical Cooperation Agreement signed between MEC, the Brazilian Ministry of Health, the National Council of Health Secretaries (Conass), the National Council of Municipal Health Secretariats (Conasems), and EBSERH (n.d.-a).

The AGHU Community currently has nearly 200 member entities, which can participate either as system users or as community managers—in the latter case, having access to the AGHU source code. Large public institutions, such as the municipal health departments of Rio de Janeiro and São Paulo, the Oswaldo Cruz Foundation (Fiocruz), and the Conceição Hospital Group (GHC), are part of the AGHU Community.

In 2025, AGHU became the first electronic health record system in the public sector to obtain NGS1 certification from the Brazilian Society of Health Informatics (SBIS), attesting to its compliance with the highest standards of security, traceability, and legal validity required for the elimination of paper use in clinical records (SBIS, 2025). The SBIS NGS1 certification requires compliance with 198 technical requirements related to the protection of personal data and the efficient use of the system by healthcare teams. As security measures, it includes the encryption of data in transit and of electronic documents containing identified health data, the continuous audit log recording, the segregation of access to medical records according to professional profiles and hospital sectors, the export of anonymized clinical reports, and emergency access to medical records by sectors that were not previously authorized.

This certification also brought a set of functional improvements to AGHU, such as the structured registration of drug and food allergies, the scheduling of medical and nursing prescriptions, bedside verification of prescriptions, the ability to attach results of tests performed in an external environment, the registration of orthotics and prosthetics, and the registration of consent forms, among others.

Furthermore, this certification enables most internal hospital processes to operate 100% digitally, eliminating the need to print clinical documents, as the system incorporates advanced electronic signatures. This type of signatures, as defined in Law No. 14.063/2020, cumulatively meets the following criteria:

a) It is uniquely associated with the signatory.

b) It uses data for the creation of the electronic signature that is under the exclusive control of the signatory, allowing, with a high level of confidence, their identification.

c) It is linked to the data associated with it in such a way that any subsequent modifications are detectable.

Chapter IV of Federal Law No. 14.063/2020 establishes that, in matters of public health, medical and healthcare documents may be signed with an advanced or qualified electronic signature, and that it will be valid throughout the national territory, except in the case of prescriptions for medications that are subject to special control and medical certificates, which must be signed with the ICP-Brazil standard (qualified signature). This standard, as well as a new set of functionalities, is included in the NG2 stage of the SBIS certification, whose implementation project has already been initiated by EBSERH.

In addition to AGHU, EBSERH currently has an extensive portfolio of information technology solutions connected to electronic medical records, in what is known as the "AGHU Ecosystem". Dozens of systems have been developed by the EBSERH Network hospital community that work in an integrated way with AGHU and respond to specific team demands. The University Hospital of UFMA (Federal University of Maranhão), for example, created a robust purchasing and contract management system linked to AGHU and named it "Pandora". The UFPR (Federal University of Paraná) hospital complex developed a system for managing transparent healthcare waiting lists that was ranked first in a best practices competition held by the EBSERH Internal Audit in 2024 (EBSERH, n.d.-b). At UFPR, the "Regula Mais" system was also created, enabling the full computerization of the internal regulation centers of hospitals. In Uberlândia, the Hospital das Clínicas of UFU (Clinics Hospital of the Federal University of Uberlândia) created a specific module for managing the Central Sterile Supply Department, with the possibility of barcode scanning of all surgical instruments used in the unit. The Januário Cicco Maternity Hospital, affiliated with UFRN (Federal University of Rio Grande do Norte), has created a teaching management system that allows for the registration of all activities and schedules of residents and undergraduate and graduate students.

Many of the solutions created within the AGHU Ecosystem have been used by various hospitals in the EBSERH Network, avoiding rework and redundancy of initiatives, as well as reducing the costs of creating and maintaining software. By decision of the EBSERH Executive Board, some have even become official solutions for the entire network, such as the teaching management system and the healthcare waiting list control system. The SUS institutions that are part of the AGHU Community can also use, free of charge, the integrated electronic medical record solutions developed by EBSERH.

The digital interpretation of medical images (X-rays, CT scans, and MRIs, among others) has been a historical bottleneck for the public sector in the transition to the world of smart hospitals. This is not only because the best available systems are expensive, but also because of the challenge of interoperating these systems with hospital electronic medical records, storing the generated images in an economically viable way (which requires large information technology [IT] infrastructures due to the size of the files), and ensuring remote access and interpretation by radiologists.

In partnership with the Federal University of Santa Catarina (UFSC), EBSERH now offers its network of hospitals the Telehealth and Telemedicine System (STT), which interfaces with medical imaging equipment and with AGHU itself, enabling large-scale telediagnosis. STT also enables teleconsultations integrated with AGHU and the EBSERH Network's patient application, HU Digital. Thus, with the solutions from the AGHU Ecosystem, STT is also available free of charge to any public institution within SUS, through a technical cooperation agreement with UFSC.

The partnership with UFSC also involves the creation of a National Medical Image Database, which will receive data from all EBSERH hospital units and will become, in the medium term, the largest medical image database in the country's public health sector. This project is included in the Brazilian Artificial Intelligence Plan (PBIA) published by the Brazilian government in 2025 and aims to provide support not only for teaching and research activities, but also for the development of computer vision technologies and diagnostic assistance based on AI (Ministry of Science, Technology and Innovation [MCTI], 2025).

Data visualization and intelligence within the EBSERH Network are achieved through 349 business intelligence dashboards integrated with AGHU and other corporate information systems of the company. These dashboards gather and process, often in near real-time, healthcare, operational, administrative, and financial data and information, allowing for the systematic monitoring of key performance indicators (KPI) across multiple dimensions. This includes outpatient and inpatient production, bed occupancy, average length of stay, consumption of supplies, antibiotic prescriptions, service time, adverse events, and use of operating rooms.

EBSERH has partnered with NoHarm to implement an AI solution in the Pharmacy module of AGHU, with the goal of improving medication prescription and increasing patient safety. NoHarm is a Brazilian healthtech enterprise specializing in the development of intelligent systems to support clinical decision-making, focusing on the prevention of adverse events related to medication use, such as drug interactions, allergies, inappropriate doses, and therapeutic duplication.

The adopted solution utilizes AI algorithms based on scientific evidence and updated clinical protocols, integrating seamlessly with AGHU for pharmacists. When prescriptions are recorded, the system performs a real-time contextual analysis of the patient's profile (age, weight, diagnoses, renal function, allergies, other medications in use, etc.) and issues intelligent alerts that assist professionals in decision-making.

EBSERH has an interoperability platform that connects all its hospitals, allowing for the progressive creation of unified clinical records for patients treated within the Network. This platform is based on the syntactic models defined by the HL7 FHIR (Fast Healthcare Interoperability Resources) language, according to the profiles and standards published by the National Health Data Network (RNDS) of the Brazilian Ministry of Health. Currently, the unified medical record system of the EBSERH Network provides a history of clinical care records (RAC) and hospital discharge summaries. In 2025, AGHU initiated the connection with RNDS, enabling healthcare professionals in HUF to access the primary care medical records of patients currently being treated at the hospitals.

Unlike international models or private hospitals with greater investment margins, the challenge in SUS for the implementation of smart hospitals is to build a robust and interoperable, yet cost-effective, digital infrastructure that supports healthcare professionals in patient care and, at the same time, promotes the integration and automation of administrative processes.

Investing in advanced technologies, such as AI, 5G connectivity, robotics, and IoT, should be part of a broader strategy to enable 100% digital hospitals in an economically sustainable way. For this reason, we consider it essential to use 100% public and free technological solutions, such as AGHU, and the entire portfolio of integrated technological solutions that are part of its ecosystem.

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Artificial Intelligence for equity in the digital transformation of the Brazilian Unified Health System in Recife

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Digital transformation in the health sector, in addition to being a global trend, is an imperative, a necessity recognized by the World Health Organization (WHO) as a right for all and an essential way to strengthen the health and well-being of the population (Brazilian Ministry of Health, 2020; Pan American Health Organization [PAHO], 2021). In Brazil, the Unified Health System (SUS), with its vast scope and diversity, represents a fertile and challenging field for the implementation of digital innovations. In this context, cities like Recife, located in the northeast part of Brazil, emerge as protagonists, aligning digital health strategies with the concept of smart cities, seeking socioeconomic development and improving people's quality of life (Oliveira-Neto et al., in press).

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Artificial Intelligence (AI) is emerging as a strategic tool to improve all phases of health care—prevention, diagnosis, treatment, and management of systems—allowing public health to address problems such as underfunding, workforce shortage, and rising care demands due to population aging. At the same time, caution is needed regarding the risks inherent in the use of AI, such as the protection of sensitive data, risks of opacity in clinical decisions, and the potential increase of inequalities in access to innovative technologies. In light of this, international and Brazilian guidelines seek to guide the development of AI systems aligned with the principles of fairness, privacy, representativeness, and transparency (Brazilian Internet Steering Committee [CGI.br], 2024).

This article discusses Recife's experience in implementing digital health policies, with a special focus on the application of AI. It will showcase advancements, ongoing initiatives, and success stories that demonstrate the potential of AI to optimize healthcare management, improve patient care, and promote equity in access to healthcare services. Finally, future perspectives for AI in healthcare in Recife will be explored, offering insights for strengthening digital health within the national context of SUS.

Digital transformation in healthcare in Recife: An integrated ecosystem

Recife has positioned itself as a benchmark in the digital transformation of health care in Brazil, driving the construction of a smarter city based on a citizen-centered strategy (Oliveira-Neto et al., in press). Their municipal strategy, formalized by decree in 2021 (Matta et al., 2024), transcends health and encompasses all spheres of the city government, with the central purpose of simplifying the relationship between the population and the government (Decree No. 34.737/2021). The concept of a smart city integrates ideas of innovation and democratic governance, aiming for inclusive and sustainable economic and social development (Oliveira-Neto et al., in press).

The city of Recife has implemented Conecta Recife, a unified multi-channel platform that offers a wide range of digital services, with the goal of making access to information and public services faster and more accessible to citizens. Currently, the platform offers more than 600 services and aims for "zero-click government," where citizens have proactive access to services without needing to request them, such as the automatic issuance of parking permits for senior citizens. This focus on citizen-centeredness and reducing inequalities is a guiding principle that uses technology as a tool to promote health and social well-being (Matta et al., 2024; Oliveira-Neto et al., in press).

One of the tools developed to accelerate digital transformation was the promotion of open innovation in the city. By seeking to create conducive environments that connect those experiencing the city's public challenges with those who can solve them, through agile methods and multiple pathways, Recife City Hall managed to reduce research and solution development costs and accelerate the achievement of results.

The Innovation and Open Transformation Squad of Recife (E.I.T.A! Recife) is a program based on Complementary Law No. 182/2021, which establishes the legal framework for startups and innovative entrepreneurship. The first cycle of the program took place in 2021, based on a common problem in healthcare systems: waiting lists for specialist appointments and tests. In order to address these challenges, two guiding questions were presented, related to identified root causes with the potential to be resolved through digital means. These are the questions: "How can we improve the quality of referrals made by primary care professionals?" and "How can we reduce patient absenteeism in attending scheduled examinations and appointments?". In 2025, the program was consolidated and launched its 3rd innovation cycle with more than 96 submitted proposals (Recife City Hall, 2025).

The availability of large amounts of contextualized data is a prerequisite for the development of AI applications. One of the fundamental pillars of Recife's digital health strategy is the interoperability of information systems. Recognizing the heterogeneity of databases in the Brazilian health sector, Recife has invested in the establishment of a Municipal Health Data Network (RMDS) (Matta et al., 2024), in alignment with the National Health Data Network (RNDS). This initiative seeks to improve access, integration, and efficient sharing of data and information, following international interoperability standards such as Health Level Seven Fast Healthcare Interoperability Resources (HL7 FHIR) and Open Electronic Health Record (OpenEHR) (Oliveira-Neto et al., in press).

Interoperability has enabled a comprehensive and integrated view of patients, providing healthcare professionals and citizens alike with access to clinical records, laboratory test results, and notification of compulsory aggravations (Matta, J. et al., 2024). A notable achievement is the integration of the Recife network with the network of the Brazilian Company of Hospital Services (EBSERH), which enables access to information on patients treated in university hospitals, such as the Hospital das Clínicas (UFPE), by basic health units in Recife and vice versa. Integration not only improves the quality of care, but it also enhances network management, an essential characteristic of SUS (Matta et al., 2024).

The entire interoperability and data sharing strategy is executed with strict attention to compliance with the Brazilian General Data Protection Law (LGPD) (Law No. 13.709/2018), guaranteeing the security and privacy of sensitive health information. The Minha Saúde Conectada platform, for example, embodies the principles of the LGPD by putting citizens in control of their information. Through it, users can not only view the entire record of who accessed their information, but also actively manage consent, accepting (opt-in) or revoking (opt-out) the sharing of their data, ensuring the principles of purpose, transparency, and free access.

AI in action: Success stories in Recife

Recife has been developing the potential of AI in practical applications in health care, seeking solutions to complex challenges faced by SUS. The following section will describe some successful innovation experiences using AI. One of the biggest challenges for Brazilian municipalities is the difficulty of consolidating and accessing up-to-date registration data for their citizens, especially telephone contact information, which is essential for any entity seeking to implement proactive actions.

To overcome the historical fragmentation of public records and build an integrated view of the citizen, the Recife City Hall created Conecta Cidadania. This initiative centralizes information from various government sources on a single platform, providing a 360º understanding of citizens' realities. This integration allows the government to understand the needs of the population more broadly and accurately. With this solid database, it becomes possible to develop more effective communication and offer proactive and personalized public services, aligned with the real needs of each citizen.

From this unified repository, the system employs computational inference techniques to generate intelligent markers that identify the life trajectories and milestones of each individual, such as birth, entry into the labor market, motherhood, and active aging. This analytical layer enables the anticipation of demands and the proactive offering of public services, contextualized to the individual and social realities of citizens.

This data architecture underpins the municipal motto "Simplify, Promote and Care" (SPC), operationalizing its three strategic pillars. Conecta Cidadania simplifies access to public services through intuitive interfaces, promotes socioeconomic opportunities through targeted policies, and offers specialized care to populations in situations of social vulnerability. In this way, the platform converts data into strategic instruments for public management, expanding equity in access to rights, strengthening the exercise of citizenship, and enhancing the state's capacity to produce positive and measurable social transformations.

One of the chronic challenges of the health system lies in the high rate of patient absenteeism at scheduled specialist appointments and complex laboratory tests, which in some areas can reach 60% of the responsible professional's schedule (Matta et al., 2024; Toker et al., 2024). To address this issue, the city of Recife launched a public challenge aimed at reducing absenteeism in the first cycle of open innovation, held in 2021 (Recife City Hall, 2025). From this process, Absens was developed, which encompasses:

- A proactive communication strategy was implemented through reminders sent to citizens via the official city hall WhatsApp (Conecta Recife) 30, 15, 5, and 3 days prior to the appointment or exam. Considering the potential reading and writing difficulties faced by some of the population, this communication is conducted in audio format, using AI "text-to-speech" and "speech-to-text" technologies, where citizens interact with a robot via voice. In addition to receiving messages, citizens have the option to interact with the platform to check their appointments, with this interaction being possible via WhatsApp, the Conecta Recife app, or the portal.

- Two-way communication occurs when the patient is notified about the appointment. They can confirm their attendance, request rescheduling, or cancel the procedure if it is no longer necessary. In the last two situations, the slots are reused for new appointments.
- Predictive overbooking is a strategy that uses AI to estimate the probability of a patient missing an appointment. Absens' machine learning algorithm analyzes multiple factors and can predict, with up to 96% accuracy, whether a user will be absent from an appointment, automatically making new slots available for overbooking based on data and AI.

The Absens tool enabled the reuse of over 300,000 appointment slots for consultations and exams, resulting in greater efficiency in the allocation of public resources—it is estimated that this led to savings of approximately R$ 21 million. Thus, optimization in filling slots, reduction in waiting times, and increased access were observed, which strengthened equity in the provision of care.

Another application currently in use in the municipality, called Integra.ai, aims to improve the process of referring patients from primary care to specialized care. One solution developed to act as a co-pilot for healthcare professionals in the e-SUS Electronic Patient Record (Electronic Citizen Record of e-SUS Primary Care), the largest national public electronic medical record system, was its integration with a regulatory system, such as Sisreg, a public solution offered by the Brazilian Ministry of Health.

Integra.ai supports primary care physicians, nurses, and dentists to perform clinical record keeping in a qualified manner, including the submission of referrals to specialized care, in accordance with municipal access protocols. A robot captures this qualified information from the medical record and automatically inputs it into the regulatory system, eliminating the need for paper-based process and intermediaries, reducing errors, and ensuring that the regulating physician receives accurate clinical information for decision-making, avoiding unnecessary returns and contributing to the assertiveness and precision of predictive overbooking AI. In September 2025, 1,136 professionals in 150 primary healthcare units in Recife used the tool.

AI is also being used to enhance communication and engagement with citizens across various Conecta Recife services. The platform uses large language models (LLM) trained with the municipal service charter to interact with citizens in natural language, answering questions about the 128 available health services. One example is the guidance on dengue vaccination, as well as information on access to the vaccine, which allows citizens to get their most common questions answered by the chatbot. LLM resources also facilitate access to communication channels with the population, such as reporting mosquito breeding sites that transmit dengue fever, using geolocation to send information directly to epidemiological surveillance, and speeding up control actions.

Furthermore, gamification strategies, using the social currency Capiba, encourage engagement in health promotion activities (e.g., attendance at Academia Recife), offering virtual bonuses that can be exchanged for tickets or discounts with city hall partners (Oliveira-Neto et al., in press). This links technology to healthy behaviors, aiming to improve population health.

Recife is using AI to identify women at higher risk of developing breast cancer, prioritizing their attention and care. This pioneering initiative within SUS is based on blood count tests performed at the Municipal Public Health Laboratory, which are analyzed using a machine learning model. This approach is consistent with the findings of the study published in Scientific Reports (Araujo, 2024), which demonstrated that the variables, when combined, allow women to be classified into different risk levels (high, moderate, typical, and low) for the development of breast cancer, with robust and fully interpretable performance.

The risk-based screening strategy contributes to early detection, reducing the time to disease detection, a critical challenge in Brazil. The experience is in the pilot phase in Recife (September 2025), representing an important step towards making care more preventive, targeted, and efficient, based on data and science.

Lessons learned

The implementation of AI tools in public health, especially in a country with profound regional and social inequalities like Brazil, requires an integrated approach that carefully considers multiple factors. The Recife experience provided relevant lessons that go beyond technical results and allow for reflection on how to conduct digital innovations in SUS. More than just implementing systems and algorithms, the process showed that digital transformation requires institutional alignment, societal engagement, and ethical responsibility in the use of data.

As a starting point for this reflection, the vision established by the organization with the definition of a comprehensive strategic plan (Recife City Hall, 2021) boosted the commitment of all city hall departments to activating plans and actions for digital transformation, according to a "government as a platform" model. This approach is based on the principles of openness, interoperability, and reuse of data and services, aiming to provide more efficient, transparent, and citizen-focused public services.

One of the first lessons learned was the importance of investing in interoperability as a structural pillar. Coordination between information systems and the need for standardization and the processing of large volumes of data is crucial for the proper functioning of AI algorithms. Recife has been overcoming the problem of fragmented health information systems and advancing in the integration of databases to ensure a unified view of citizen care.

The adoption of an interoperability bus and its applications for users (My Connected Health) and professionals (Networked Electronic Health Record) has enabled easier access to health information, brought efficiency to care, and strengthened decision-making based on clinical history. The model adopted by the municipality, aligned with international standards, demonstrated that only with an integrated view of patients is it possible for AI solutions to have a real impact on care. This solid foundation was essential to enabling projects such as data sharing with university hospitals, expanding the reach and quality of the care network.

Another key point was the emphasis on open innovation as an acceleration strategy. The E.I.T.A! Recife program has shown that the collaboration among government, academia, startups, and civil society generates faster and more effective solutions, reducing development costs and stimulating the local ecosystem. Based on real-world problems, such as absenteeism at appointments, it was possible to co-create AI tools that optimized the filling of hundreds of thousands of slots, improving the population's access to specialized services. It is also noticeable how much this movement has fostered a culture of innovation in City Hall, revitalizing planning and execution methods within an environment that includes creativity as a driving force for the organization.

It also became clear that citizen-centered approaches should guide innovation. Proactive communication via WhatsApp with audio accessibility features, the smart service catalog, and healthcare gamification initiatives have shown that technology only becomes effective when it engages with the reality of the population. This learning reinforces the need to consider barriers such as digital literacy and inequalities in access, which increase the risk of widening gaps instead of reducing them.

In the field of governance, experience has demonstrated the relevance of ethics and transparency in the adoption of AI. Issues such as the protection of sensitive data, the explainability of algorithms, and the representativeness of databases were constantly discussed. The use of AI to predict breast cancer risk, for example, has shown that high-impact technologies need to be anchored in robust clinical protocols and proactive search strategies that ensure equity in healthcare provision.

Despite the progress, ensuring a robust technological infrastructure and quality connectivity, especially in less developed areas, is essential for the entire information management flow within SUS, yet it remains an obstacle in most Brazilian municipalities. Recife seeks to keep its technological infrastructure up-to-date, with stable and redundant connectivity in healthcare units, and to provide integrated systems that allow quick access to clinical information.

In 2021, only the Family Health Units were fully computerized. With significant investment in recent years, by 2025, in addition to primary health care (PHC), 100% of medium and high complexity units, such as hospitals and polyclinics, will also have full computerization. The city government maintains a data center with high availability with reinforced security, based on redundancies in both power supply and Internet connectivity, to ensure 99.982% uptime.

There is a shortage of professionals specializing in digital health and data scientists with specific knowledge in the healthcare field. Ongoing training for healthcare professionals and managers is essential for the effective adoption and use of technologies. In this context, the Recife Health Department has invested in fostering a Center for Continuing Education in Digital Health, with facilitators working in a decentralized manner throughout the territory, close to health districts, health units, and communities. Furthermore, at the central level, it has a management team focused on digital transformation and a healthcare business analytics team performing strategic functions. The business analyst acts as a link between the technical, care, and management areas, ensuring that the solutions developed, structuring processes, and operational needs meet the real demands of the healthcare network.

Finally, the Recife journey highlighted the importance of continuous learning and scalability. Each pilot project, whether in prevention, citizen engagement, or smart regulation, was understood as part of an iterative process. Positive results, such as reduced absenteeism and integration between levels of care, reinforce the need to institutionalize these practices, expanding them to other areas and ensuring their sustainability over time, regardless of administrations, as a consolidated state policy.

In short, the municipality understood that digital transformation in health care is not limited to the technological realm: It also encompasses the social, ethical, and political spheres. The application of AI in the context of SUS has proven viable and promising, but requires solid foundations of interoperability, responsible governance, and a continuous focus on equity. These lessons serve not only the reality of Recife, but the whole of Brazil, as a reference for showing that it is feasible to employ cutting-edge technology to strengthen the public and universal health system.

Future prospects

The path taken by the city of Recife demonstrates that AI, when used ethically and responsibly, can be a powerful tool to strengthen SUS, expand access, and improve the quality of health services. Future prospects include strengthening interoperability and developing AI applications with a broader impact on population health and healthcare system management.

Expanding interoperability is necessary to continue advancing the integration of systems at the municipal, state, and federal levels, so that SUS functions as a cohesive and intelligent data network, including the complementary and private systems. The inclusion of interoperability, based on international standards, as a prerequisite for any new solutions developed for the SUS, is an important requirement for this movement.

In Recife, some initiatives are in the development or prototyping phase, with availability expected during 2026. These are: 1) AI agent on WhatsApp to assist users in scheduling services at primary health units; 2) AI agent to assist healthcare professionals in completing electronic health records; 3) AI agents to support both users and healthcare professionals in the care of hypertension and diabetes; 4) AI agent on WhatsApp to clarify users' doubts regarding health services offered by the municipal network; 5) AI to support the early detection of breast cancer (risk-organized screening).

At the national level, although still scarce, there is a need to encourage the production of knowledge and AI based technologies adapted to the cultural and epidemiological specificities of Brazil. This is essential to promote technological sovereignty and avoid dependence on foreign solutions.

For health system management, there is a fertile path for the use of AI in supporting the formulation of public policies, detecting anomalies in health system data, optimizing public procurement, and conducting epidemiological monitoring, allowing for faster responses to outbreaks and health emergencies. For citizen monitoring, there is an increasing use of AI to personalize and strengthen patient-centered care, offering clinical decision support for professionals, and developing mechanisms that prevent hospitalization and promote self-care.

To achieve this, investment in continuing education must be expanded, prioritizing specialization programs in AI and digital health for all levels of professionals in SUS, from frontline workers to management. Strengthening governance and regulation is essential to establishing a clear and dynamic regulatory framework that ensures the ethical, safe, and transparent use of AI, with accountability mechanisms and protection of personal data, in line with WHO recommendations.

Recife can serve as a valuable laboratory for the future of digital health in Brazil. Collaboration among municipalities, states, the federal government, academia, and the private sector is crucial to scaling these initiatives, addressing persistent challenges, and ensuring that the benefits of AI in health care are equitably distributed to the entire Brazilian population.

Final considerations

The experience demonstrated by Recife shows how digital transformation in health care can be a structuring element for strengthening SUS. The initiatives implemented in the municipality, along with strategic planning, governance, and monitoring, were able to produce tangible results in terms of efficiency, quality of care, and user engagement.

The cases analyzed—such as the use of predictive algorithms to reduce absenteeism, the integration between electronic medical records and regulatory systems, and the application of AI for citizen engagement—point to a trend of evolving health care towards more proactive, predictive, and personalized models. These advances, however, require attention to persistent challenges, such as data standardization and integration, ensuring adequate technological infrastructure, continuous professional training, and establishing robust regulatory frameworks that guarantee ethics, transparency, and security in the use of AI.

Alignment with Digital Health Strategy for Brazil 2020-2028 (Brazilian Ministry of Health, 2020) is an opportunity to strengthen data infrastructure, interoperability, professional training, and the participation of multiple stakeholders in this transformation. It is necessary to strengthen regulatory instruments, ensure equity in algorithms, and promote the leading role of SUS in integrating innovative solutions, avoiding social and regional biases.

A public policy of digital transformation, such as the one Recife has been promoting, can make the use of AI also a structuring intervention in favor of equity in access, distribution of benefits, and protection of the rights of users of the Brazilian public health system (CGI.br, 2024). Brazilian legislation, such as LGPD (Law No. 13.709/2018), provides a framework, but a specific regulation for AI is still under debate and needs to be strengthened to protect the public interest (Matta et al., 2024)

From a scientific standpoint, the Recife experience provides valuable insights for the debate on incorporating emerging technologies into public health, offering evidence that open innovation approaches and collaborative ecosystems can enhance the development of cost-effective solutions adapted to the local context. Looking ahead, further study is recommended of impact assessments, cost-effectiveness measurements, and equity analysis of access to digital solutions, in order to guide evidence-based public policies and ensure that the benefits of digital transformation are distributed fairly and inclusively.

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List of Abbreviations

AGH – Hospital Management Application

AGHU – Management Application for University Hospitals

AHRQ – Agency for Healthcare Research and Quality

AMS – Survey of Medical-Sanitary Assistance

ANS – National Supplementary Health Agency

ATIH – Agence Technique de l'Information sur l'Hospitalisation

BI – *business intelligence*

CATI – *computer-assisted telephone interviewing*

CBO – Brazilian Occupational Classification

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

CFM – Federal Council of Medicine

CGI.br – Brazilian Internet Steering Committee

CNES – National Registry of Healthcare Facilities

Conasems – National Council of Municipal Health Secretariats

Conass – National Council of Health Secretaries

Cosems – Council of Municipal Health Secretariats

CRAFT-MD – Conversational Reasoning Assessment Framework for Testing in Medicine

Datasus – Department of Informatics of the Brazilian Public Health System

DREES – Direction de la Recherche, des Études, de l'Évaluation et des Statistiques

DRG – Diagnosis Related-Group

E.I.T.A! Recife – Innovation and Open Transformation Squad of Recife

EBSERH – Brazilian Company of Hospital Services

ECLAC – Economic Commission for Latin America and the Caribbean

EEG – electroencephalogram

EHR – electronic health record

ESD28 – Digital Health Strategy for Brazil

Fiocruz – Oswaldo Cruz Foundation

FP – for-profit

FTE – full-time equivalents

GHC – Conceição Hospital Group

HCPA – Hospital de Clínicas de Porto Alegre

HL7 FHIR – Health Level Seven Fast Healthcare Interoperability Resources

HU – university hospitals

HUF – federal university hospitals

IA – Artificial Intelligence

IBGE – Brazilian Institute of Geography and Statistics

ICD – International Classification of Diseases

ICT – information and communication technologies

ICU – Intensive Care Unit

IoT – Internet of Things

IT – information technology

KPI – key performance indicators

LGPD – Brazilian General Data Protection Law

LLM – large language model

MCQ – multiple-choice question

MCTI – Ministry of Science, Technology and Innovation

MEC – Ministry of Education

NCCN – National Comprehensive Cancer Network

NFP – not-for-profit

NIC.br – Brazilian Network Information Center

OECD – Organisation for Economic Co-operation and Development

OpenEHR – Open Electronic Health Record

PAHO – Pan American Health Organization

PBIA – Brazilian Artificial Intelligence Plan

PHC – primary health care

PMSI – Programme de Médicalisation des Systèmes d'Information

RAC – clinical care records

RMDS – Municipal Health Data Network

RNDS – National Health Data Network

SADT – diagnosis and therapy services

SBIS – Brazilian Society of Health Informatics

Seidigi – Digital Health and Information Secretariat

SPC – Simplify, Promote and Care

SQL – structured query language

STT – Telehealth and Telemedicine System

SUS – Unified Health System

UBS – Primary Healthcare Units

UFPE – Federal University of Pernambuco

UFPR – Federal University of Paraná

UFRN – Federal University of Rio Grande do Norte

UFSC – Federal University of Santa Catarina

UFU – Federal University of Uberlândia

UNESCO – United Nations Educational, Scientific and Cultural Organization

USMLE – US Medical Licensing Exam

WHO – World Health Organization

WHO-Europe – WHO Regional Office for Europe

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of UNESCO

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Information Society

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