



COUNTRY REPORT

Radiology in Brazil: A Country Report

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Abstract

Objective: The purpose of this country report is to analyze the state of radiology in Brazil from its origins to its present state. We detail both the country's advancements in the field and the areas that could stand to be improved, including increased access to radiology in its less populous, more rural regions. We detail the imaging equipment available in the country and seek to stratify this data among different geographic areas.

Materials and Methods: The review was completed using the University at Buffalo catalog and database search. A search was conducted for both U.S. and Brazil based journal articles focused on radiology in Brazil. A general Google search for articles was conducted to obtain information regarding the socioeconomic status and history of Brazil. The Brazilian government's health system database website was used to obtain data regarding the availability of different diagnostic equipment.

Results: Brazil is the largest radiology market in Latin America. It has taken great strides over the past few decades to advance its work in the radiology sector. There are two main areas still in need of improvement: first of all, providing diagnostic imaging resources to remote and rural regions, and second of all, expanding the use of PACS software to all hospitals.

Conclusion: The state of radiology in Brazil has vastly improved over the past few decades. Continued investment in diagnostic imaging equipment — while prioritizing less populous and poorer areas — will help both the field of Brazilian radiology and the individuals it serves.

Introduction

Brazil (Federative Republic of Brazil) is a South American country bordered by every other South American country except for Chile and Ecuador. The fifth largest country in the world, Brazil has a total area of 8,515,770 km² (3,287,957 square miles) and is shaped as a large irregular triangle. The population of Brazil is approximately 218 million, making it the seventh most-populous country in the world and the most populous country in Latin America (1). The life expectancy of Brazilians as of 2023 is 72.5 years for males and 79.6 years for females, and ~94% of the population over the age of 15 is literate (1).

Brazil consists of 26 states and one federal district, as shown in Figure 1 (2). The Brazilian government has divided the country's states into five geographic units, referred to as the Major Regions: North, Northeast, Central-West, Southeast, and South (1). The largest portion of the Amazon rainforest is in the North and the country's largest population density is in the Southeast (1).

History and government

In 1500, the Portuguese made their first contact in Brazil when the navigator and military commander Pedro Álvares Cabral was sailing for India (3). Cabral landed on the northeast coast of South America, specifically Porto Seguro, a city located in what is now the state of Bahia. The region was claimed by Portugal and initially named Vera Cruz but soon renamed Brazil for the large amounts of brazilwood (pau brasil) found there (3).

In 1549, Portugal’s monarchy established a Governorate General of Brazil, served by Tomé de Sousa until 1553 (3). Sousa established Salvador as the first capital of Brazil. However, the gold rush in the late seventeenth century, especially in the southeast state of Minas Gerais, substantially impacted the economy and development of the region, and the large sums of money from gold, diamonds, and emeralds mined there led to the relocation of the capital to Rio de Janeiro in 1763 (3). In 1960, the capital was again changed to its current city, Brasília (3).

In 1808, the royal family of Portugal fled to Rio de Janeiro to escape the French invasion of Portugal and began initiating changes in Brazil (3). Dom João VI, prince regent of Portugal, established universities, the Bank of Brazil, the Supreme Court, and the Royal Mint (3). He sailed back to Portugal in April 1821 after the defeat of Napoleon’s French forces, leaving his son, Dom Pedro I, to govern (3). On September 7, 1822, Dom Pedro I proclaimed Brazil’s independence and established the Brazilian empire. He was crowned emperor on December 1st, 1822, and ruled until 1831, when his son, Pedro II, took over (3). Slavery was abolished in 1888, and Dom Pedro II was removed from power the next year, leading to Brazil’s first republican government (3).

In 1930, Getúlio Vargas seized power via a military coup (1,3). In 1945, another coup took place that removed Vargas from office. He returned to the presidency in 1951, only to commit suicide in 1954. In 1964, another coup took place with the overthrow of João Goulart, leading to 21 years of military rule (3). In 1988, after a new constitution was drafted, Brazil returned to democracy (3).

Today, Brazil’s government has three branches: the executive, legislative, and judicial branches. Legislative power is bestowed on the National Congress, consisting of the Federal Senate and Chamber of Deputies. The Federal District and each of the states elects three representatives for the senate, where they serve eight year terms (1). The Chamber of Deputies consists of 513 members who are elected for four year terms by proportional representation (4). Elections for Federal Senate and Chamber of Deputies are held every four years. Brazilian presidents are elected to a four year term via a two-round system (1).

Socioeconomic status

The Brazilian Economic Classification Criteria were developed by the Brazilian Association of Research Companies to stratify the population according to socioeconomic levels (5). The criteria use a point system according to various household

Figure 1. Map of Brazil (2).



Table 1. Brazilian Economic Classification Criteria point system for variables affecting socioeconomic status.*

Variable	Points awarded per quantity of each item				
	0	1	2	3	4+
Bathroom(s)	0	3	7	10	14
Domestic worker(s)	0	3	7	10	13
Automobiles(s)	0	3	5	8	11
Personal computer(s)	0	3	6	8	11
Dishwasher(s)	0	3	6	6	6
Refrigerator(s)	0	2	3	5	5
Freezer(s)	0	2	4	6	6
Washing machine(s)	0	2	4	6	6
DVD player(s)	0	1	3	4	6
Microwave oven(s)	0	2	4	4	4
Motorcycle(s)	0	1	3	3	3
Clothes dryer(s)	0	2	2	2	2

*Data as of 2022 (6).

aspects (Tables 1 to 3). While there are many methods to stratify the socioeconomic status of Brazilian citizens, among the most widely used include marking classes with letters from A to E. Those in class A have a higher socioeconomic level while those in level E are at a lower level. The Central-West region has the highest percentage of citizens in class A (4.8%), while the Northeast region has the highest percentage of citizens in class D-E (46.3%) (6).

Table 2. Brazilian Economic Classification Criteria Socioeconomic status points earned for education and utility service availability.*

Category	Points
Household education	
No schooling	0
Elementary school diploma	1
Junior high school diploma	2
High school diploma	4
Higher education degree	7
Availability of public utility service	
Piped water	4
Paved street	2

*Data as of 2022 (6).

Medical Environment

Public health care

Health care is considered a constitutional right in Brazil. The Brazilian health care system has public and private components. The public system is referred to as Sistema Único de Saúde (SUS), which is universal and free for all Brazilian citizens. Each citizen is issued an SUS card that they bring to all appointments. Some services that are free of charge include preventative services, primary care, vision care, maternity care, and dental care (7). The Ministry of Health is responsible for administering health policy (7). Brazil spends approximately 9.59% of its gross domestic product on health expenditures, the third highest proportion in Latin America behind Cuba (11.34%) and Suriname (9.74%) (8). Of the 9.59% of Brazil's gross domestic product that goes towards health care, 56% is spent on private health care, while 44% goes towards public health care (9). Funding for health care comes from federal, state, and municipal levels. By law, states must contribute at least 12% of their total revenue to public health care, whereas the federal and municipal governments must contribute at least 15% (7). In 2017, the federal government was responsible for 43% of health care funding while states provided 26% and municipalities contributed 31% (7).

A hallmark of the SUS program is the Programa Saúde da Família (PSF). Originally established as a pilot program in the state of Ceara in 1994 to provide free care to one million citizens, it is a primary health care program that has worked to provide care and preventive services at the community level (10). The primary care team of the PSF consists of a physician, nurse, nurse's assistant, social worker, and up to six community health workers. These units provide care to approximately 3,500 residents at local health facilities (10). By 2014, there were more than 37,300 health care teams that provided care for 60% of the nation's population (10). The adoption of PSF led to substantial decreases in heart disease, stroke, and hospitalizations. It is estimated that the PSF program saved more than 450,000 lives between 1996 and 2012 (10).

Table 3. Brazilian Economic Classification Criteria thresholds and average income.*

Points	Socioeconomic level	Average monthly household income (\$)	
		BRL	USD
45–100	A	21,826.74	4,318.62
38–44	B1	10,361.48	2,050.11
29–37	B2	5,755.23	1,138.73
23–28	C1	3,276.76	648.34
17–22	C2	1,965.87	388.97
0–16	DE	900.60	178.19

*Data as of 2022 (6). BRL, Brazilian real; USD, US dollar.

The Programa Mais Médicos was launched in 2013 by the government in order to help alleviate some of the shortage of physicians in the country. The program brought foreign physicians in to the country to help individuals in more remote and underserved regions where establishing care is difficult. The program had a particular focus on expanding primary care access for patients (11).

While the SUS has been successful in caring for the large proportion of Brazilian citizens, it has experienced setbacks by being underfunded while also competing with the private sector. For example, in December 2016, the Brazilian congress passed a constitutional amendment that limited federal expenditure on health to inflation for the next 20 years (12). It is estimated that over the 20 years the amendment will exist, the federal health budget will lose almost \$467 billion BRL (\$93 billion) (12). The COVID-19 pandemic further increased the stress on the public health care system.

Private health care

Private health insurance is voluntary. As of 2019, private insurance was held by 22.7% of the population (13). Around 70% of them obtained it as an employment benefit (7). The private health sector in Brazil is the second largest in the world, behind that in the United States (7), and is regulated by the National Agency of Supplementary Health. Some popular health insurance companies in Brazil include Amil Assistência Médica (owned by US-based UnitedHealth Group), Bradesco Saúde, and NotreDame Intermédica (14).

Private health plans offer services through their own facilities or certain accredited health care centers. Private insurance companies can also reimburse enrollees for services they receive. Access to private health care varies depending on region. The North region has the lowest rate of private health coverage (9%), while the South has a coverage of 23% (9).

Other differences between the public and private sectors include shorter wait times for those who utilize private care. Private medical coverage also has the benefit of a smaller patient to physician ratio while also allowing access to newer medical equipment.

Hospitals and workforce

There are upwards of 6,800 hospitals in Brazil (15), approximately 4,200 of which are private hospitals (16). 41% of private hospitals are located in the Southeast region (16). As of 2018, Brazil had 451,777 physicians, 63% of whom are specialists; the remainder are general practitioners (7). The majority of physicians and hospitals are located in urban areas, which is disadvantageous for people living in rural settings. There are approximately 2.3 million nurses in Brazil (17).

As of 2018, there were 10,327 diagnostic radiologists in Brazil and 324 radiologists specializing in interventional and angioradiology (13). Of the 55 specialties in Brazil, radiologists comprise 3% of the total physician workforce (13). There are approximately 6.17 radiologists per 100,000 inhabitants. The distribution of specialists, however, varies according to geography (13). For example, there are 2.34 radiologists per 100,000 inhabitants in the northern state of Pará, whereas the Federal District in the Central-West has 16.34 radiologists per 100,000 inhabitants (18).

There are two categories of certifications for medical physicists: radiation protection supervisor provided by the National Commission of Nuclear Energy and a specialist certificate provided by the Brazilian Association of Medical Physics. As of 2017, there were 295 radiation protection supervisors working in nuclear medicine and 444 in radiotherapy (19). As of 2017, there were 1,345 active members of the Brazilian Association of Medical Physics, including 306 medical physicists specializing in radiotherapy, 82 in diagnostic radiology, and 42 in nuclear medicine (19). A large proportion of the physicists are located in the Southeast region.

Pharmacy services

As of 2019, Brazil had 114,352 community pharmacies and upwards of 221,000 pharmacists (20). Approximately 77% of the community pharmacies are privately owned (20). Public pharmacies tend to keep a seven day stock pile of medicines, but do not always have a pharmacist on duty. These pharmacies sometimes have trouble obtaining patients' medical records. Many private pharmacies are open 24 hours a day and have a pharmacist on site at least 8 hours a day. Patients are able to have private consultations with pharmacists and obtain larger supplies of medicines (20).

In 2004, the federal government of Brazil created the Farmácia Popular do Brasil program to help increase access to several medications. Under the program, certain essential medications used for common diseases are covered by the federal government in public and private pharmacies. Medications for hypertension, diabetes, and asthma are dispensed to patients free of charge, whereas medications for osteoporosis, dyslipidemia, and Parkinson's disease are subsidized up to 90% (21).

Disease profile

As of 2019, ischemic heart disease was still the leading

cause of death among Brazilians, followed by stroke and lower respiratory infections (22). However, there has been a substantial drop in the number of deaths resulting from neonatal disorders in the past decade. Rates have dropped by 41% in that time: in 2009, neonatal disorders were the sixth leading cause of death in the country. By 2019, they were the thirteenth listed cause (22). The top risk factors leading to death and disability in Brazil today are a high body mass index and high blood pressure. Malnutrition was the leading factor driving death and disability in 2009. Over the last decade, it dropped 36% and was listed as the seventh leading cause in 2019 (22).

Radiology environment

Radiology history

In 1897, two years after Wilhelm Conrad Roentgen discovered X-rays in Germany, the first X-ray machine was installed in Formiga, Minas Gerais, by physician José Carlos Ferreira Pires. The first radiology class was taught by physician João Américo Garcez Fróes at the Faculdade de Medicina da Bahia in 1903 (13). However, the first official course in radiology did not begin until July 15th, 1916, at the Universidade Federal do Rio de Janeiro, taught by Roberto Duque Estrada with lessons drawn from the Radiology Bureau of the Hospital Santa Casa de Misericórdia in Rio de Janeiro (23).

The first society of radiologists in Brazil was founded in 1929 and named the Brazilian Society of Radiology and Electrology. In the 1930s, two more radiology courses were created in Rio de Janeiro: one by José Guilherme Dias Fernandes at the Faculdade de Medicina do Instituto Hahnemaniano and another by Manoel de Abreu at the Faculdade de Ciências Médicas (13). Abreu gained popularity for his invention of "abreugraphy," also known as miniature chest radiography, a technique to screen for tuberculosis (24). His contribution led to the development of a new radiology society, the Sociedade Brasileira de Abreugrafia in 1957, and the publication of the Revista Brasileira de Abreugrafia (13).

The Colégio Brasileiro de Radiologia e Diagnóstico por Imagem (CBR) was founded on September 15th, 1948, and is the official body responsible for the oversight and practice of radiology in Brazil (25). The first radiology residency program in Brazil was developed in 1952 by Nicola Caminha and Waldir Maymone at the Hospital Federal dos Servidores do Estado in Rio de Janeiro, and the first radiology department was established in 1972 at the Universidade Federal do Rio de Janeiro (13). The first computed tomography (CT) scanner was installed at the Hospital da Real e Benemérita Sociedade Portuguesa de Beneficência in São Paulo in 1977 (13).

Medical school and radiology training

Brazil follows the European model of a six-year medical school program, after the completion of which students are awarded the degree of physician (grau de médico) (25). Graduates who wish to go into a specialty must pass through two or three stages (depending on the program's discretion) before

acceptance. Graduates must first take an objective multiple-choice exam and then a practical test regarding basic areas of medicine. Finally, a curriculum review and interview are performed (25).

There are three types of radiology specialties: radiology and diagnostic imaging, general ultrasonography, and interventional radiology and angioradiology. Radiology and diagnostic imaging is the most common specialty, with approximately 70% of radiologists holding this title (13). Interventional radiology and angioradiology is the least common, with only 324 interventionalists in Brazil as of 2019 (13). There are two ways for physicians to obtain specialization in radiology and diagnostic imaging: by completing a three year residency program overseen by the Ministry of Culture or by completing a CBR-accredited three year radiology and image diagnosis improvement course (13,25). As of 2022, there are 146 residency programs recognized by the Ministry of Culture and 98 programs accredited by the CBR (26). There are 24 ultrasonography programs, all accredited by the CBR (26). Unlike that in neighboring Uruguay, Brazil offers subspecialty training, and fewer than half of radiologists travel abroad for specialization. Subspecialty training opportunities include breast imaging, neuroradiology, interventional radiology, and pediatric radiology (27). As of 2022, there are 95 fellowship programs offered in Brazil, 70 of which are located in the South and Southeast regions (26). Brazil does not require research during residency, unlike Mexico, Venezuela, and Colombia (27).

Radiology training includes medical physics taught by either a radiologist or medical physicist, if one is on the clinical staff of the participating hospital (27). Certification exams are both oral and written.

Radiology market

As the population ages and the need for diagnostic imaging units and capabilities increases, the diagnostic imaging equipment market will follow suit. In 2021, the Brazilian diagnostic imaging equipment market was valued at \$998 million, the largest in Latin America, and is expected to reach \$1,450 million by 2027 (28). The need for more imaging equipment increased in the COVID-19 pandemic. CT, X-rays, and nuclear imaging techniques are being used more to study the lungs and progression of the disease in patients with COVID-19. In 94 hospitals and clinics from 14 states, the demand for chest CT between March 1st and June 30th, 2020, increased 192% compared to that during the same period in 2019 (29). The rise of chronic diseases such as heart disease and cancer has also led to growth in the radiology equipment market. In 2018, the rates of growth were 7% for CT scanners and 9% for magnetic resonance imaging (MRI) equipment (30).

Some major companies in the diagnostic imaging equipment market include Canon Medical Systems Corporation, Carestream Health, and Esaote (28). Agfa-Gevaert is a Belgian-German corporation that also produces diagnostic equipment and information technology

software and has an office located in São Paulo (31).

Imaging software

Although picture archiving and communication system (PACS) software is widely used in Brazilian hospitals, it has not been universally adopted. Its use varies according to geographic location and hospital size. Larger hospitals and diagnostic centers, especially in the Southeast region, are often fully integrated with PACS, whereas smaller hospitals and those located in the North have not completed the transition to PACS (32).

Pixeon, a health care software development company headquartered in São Caetano do Sul, São Paulo, has become a popular local supplier of PACS software to hospitals in Brazil (33). Agfa-Gevaert is another company that produces a range of imaging systems, including PACS, that are also widely used in Brazilian hospitals (31). Santa Casa de Misericórdia Hospital in Porto Alegre, Rio Grande do Sul, one of the largest and most modern hospital complexes in the country, has nine hospitals altogether, and seven of these transitioned to Carestream Vue PACS in 2019 (34).

Teleradiology

As the population grows and the need for image interpretation increases, the need for radiologists also increases. This is particularly important for rural areas, where large populations often only have access to a limited number of radiologists. Telelaudo, founded in 2008, is a teleradiology company that provides services to hospitals and clinics in Brazil. Telelaudo employs 120 radiologists and has produced upwards of 4.7 million reports to more than 450 hospitals as of 2021 (35).

Radiology entrepreneurship

There is a large amount of untapped potential for radiology in Brazil. One method to achieve this potential is by expanding the use of PACS to all hospitals, especially those in the North and Northeast regions. Although Telelaudo has made great advances in helping large numbers of Brazilian citizens, the teleradiology market remains limited. By expanding the use of teleradiology and encouraging the growth of new companies in this domain, the Brazilian health care system can help care for a much larger proportion of the population.

Radiology equipment

According to the National Registry of Health Establishments, there are 153,758 diagnostic imaging units in Brazil, 94% of which are operational (36). Most of the imaging modalities are located in hospitals, with much fewer availability in outpatient imaging centers. Tables 4 and 5 describe various equipment modalities and quantities.

Table 4. Diagnostic imaging equipment in Brazil.*

Modality	Number of units			
	Total	In use	Available to SUS	In use by SUS
Gamma camera	816	783	432	413
Mammography with simple command	4,444	4,260	2,207	2,097
Mammography with stereotaxis	969	931	439	411
X ray (<100 mA)	7,770	7,300	3,981	3,701
X ray (100–500 mA)	13,748	13,143	8,648	8,228
X ray (>500 mA)	4,589	4,426	2,656	2,563
X ray (dental)	52,491	48,209	10,107	9,316
X ray with fluoroscopy	1,998	1,798	1,122	1,050
DEXA (bone density)	2,575	2,512	943	914
CT	6,219	6,030	3,069	2,974
Magnetic resonance imaging	3,174	3,107	1,431	1,402
Color doppler ultrasonography	19,367	18,746	7,156	6,948
Echocardiography	11,124	10,748	5,323	5,127
Conventional ultrasonography	19,095	18,249	9,320	8,871
Digital mammography	1,222	1,179	729	701
PET/CT	118	118	60	60
Total	149,719	141,539	57,623	54,776

*Data as of 2022 (36).

Diagnostic and interventional skills

X-ray

X-ray units are available throughout both public and private hospitals. As of 2022, there are 26,107 non-dental X-ray units, with 24,869 in operation. The majority of units are located in the Southeast region, with the highest number (6,173) in use in the state of São Paulo (36).

Ultrasonography

As of 2022, there are 19,095 conventional ultrasonography units, 18,249 of which are operational (36). A large proportion of these units are present in the South and Southeast regions. Doppler ultrasonography equipment is also available, to a lesser degree, with 6,948 in use by the SUS. The northern state of Roraima has the fewest conventional ultrasonography machines in use (45), whereas the southeast state of São Paulo has the most (4,331) (36).

CT

As of 2022, there are 6,219 CT scanners in Brazil, 6,030 of which are operational. The northern state of Roraima has the fewest number in use (36).

Mammography

As of 2022, there are 4,444 simple command mammography units: 4,260 in operation and 2,097 in use by the SUS. Although not as widely available, digital mammography

is becoming more popular, with 701 units now in use by the SUS (36). However, the number of mammography units is insufficient for the large population of Brazil. In 2019, 2,660,469 mammograms were performed by the SUS, but the expected number was 12,154,979, meaning the mammogram coverage for the entire country was 21.9% (37). The North region had the lowest coverage (9.8%) and the South region had the highest (26.8%) (37). In the northern state of Amapá, 26,846 tests were expected, but only 149 were performed (0.6% coverage). The highest coverage was from the southeast state of Paraná, where 215,671 tests were performed out of an expected 726,472 (29.7% coverage) (37). An important step to reduce the gap between actual and expected mammograms performed is to have operational up-to-date units, as many are out of operation and not available to the SUS.

To help increase access to mammograms in remote areas, the International Atomic Energy Agency installed a mammography unit on each of two Brazilian navy ships that will traverse the Amazon river to the borders of Colombia, Guyana, Peru, Suriname, and Venezuela and provide screening services to citizens living in these regions. In 2022, there will be eight journeys, with each lasting up to 45 days. Each ship will be able to perform up to 1,000 screenings each year (38).

Compared to Brazil, the US has more mammography units available to patients, including mobile mammography to

Table 5. Regional distribution of imaging equipment in Brazil.*

Modality	Number of units in use				
	North	Northeast	Southeast	South	Central West**
Gamma camera	52	132	390	128	43
Mammography with simple command	252	1,109	1,922	629	299
Mammography with stereotaxis	58	229	381	168	72
X ray (<100 mA)	416	1,322	3,810	1,125	518
X ray (100–500 mA)	799	2,879	6,348	1,874	1,059
X ray (>500 mA)	304	892	1,948	825	397
X ray (dental)	2,233	8,209	23,855	10,205	3,203
X ray with fluoroscopy	58	212	1,101	326	71
DEXA (bone density)	144	494	1,223	408	183
CT	387	1,132	2,766	1,023	511
Magnetic resonance imaging	183	550	1,481	550	231
Color doppler ultrasonography	1,018	3,761	8,896	3,306	1,339
Echocardiography	608	2,434	4,354	2,247	799
Conventional ultrasonography	1,334	4,556	8,265	2,516	1,220
Digital mammography	89	275	509	166	94
PET/CT	5	19	62	19	2
Total	7,940	28,205	67,311	25,515	10,041

*Data as of 2022 (36). **Data do not include the Federal District.

visit patients in their communities. This enables the US to provide this service to a wider population. In 2019, it was estimated that 76% of women between the ages of 50-74 had a mammogram in the past two years (39). In 2019, 68% of women whose income was <200% of the federal poverty level had a mammogram in the past two years (39). While data regarding a specific number of mammography units in the US could not be obtained, approximately 40 million mammograms are performed each year (40).

Breast cancer is the leading cause of cancer death among women in Brazil (41). In 2017, there were approximately 16,724 deaths due to breast cancer in Brazil (42). Screening has played a vital role in finding and addressing early cases of breast cancer. Access to mammography varies by region as well. Data from 2019 showed that 41.9% of women in the Northeast state of Maranhão never had a mammogram (41). Increasing access to routine mammography throughout the country, particularly in the North and Northeast regions will likely have a strong impact on reducing morbidity and mortality due to breast cancer.

PET/CT

Positron emission tomography (PET) was first introduced to Brazil by the SUS in 2014. Between 2015 and 2019, 86,807 PET/CT scans were performed in Brazil, almost half of which were performed in the Southeast region (43). As of 2022, there are 118 PET/CT units, all of which are operational (36).

Although the introduction of PET/CT to Brazil's health care system is relatively new (compared to X-ray and CT), the use of this modality is expected to increase. PET/CT should be made more available to the North and Central-West regions. Of the seven northern states, only Amazonas (one unit) and Pará (four units) have PET/CT machines (36).

MRI

As of 2022, there are 3,174 MRI machines, 3,107 of which are operational (36). Hospital do Coração, in São Paulo, is the first hospital in the country to offer 3T MRI (44).

Fluoroscopy

As of 2022, there are 1,998 fluoroscopes in Brazil: 1,798 of these are operational and 1,050 are in use by the SUS (36).

Equipment service

Associação Brasileira da Indústria de Tecnologia para Saúde (Abimed) is the main entity promoting the implementation of policies and regulations that ensure that medical equipment is safe to use (45). Abimed cooperates with the Agência Nacional de Vigilância Sanitária (Anvisa), which works to protect the population's health via sanitary control of the production, marketing, and use of products in the health field (46).

Abimed emphasizes that it is important that only authorized companies perform maintenance service on medical equipment. These companies should have specific training and do refresher courses continuously to help ensure proper

functioning of the equipment. According to federal law, manufacturers or device registration holders must ensure the safety and efficacy of the products to the consumer. When a manufacturer or authorized representative installs a product, the manufacturer or representative must verify that it works according to established criteria and the verification must be recorded. Manufacturers must also maintain technical assistance records that identify the product subject to service, the control number used, the date the service was performed, service provider identification, a description of the services performed, and the results of inspections and tests (45).

Health care institutions and providers are also responsible for the proper functioning of equipment. They must ensure that any technical assistance they need for a product in their custody is conducted by an authorized representative and that records are kept regarding the maintenance of the equipment. When the product is specifically used for diagnostic or interventional use, health care institutions must keep records of certificates issued and technical assistance services completed for at least five years (45).

Job opportunities

Radiology

Although many large Brazilian cities have a sufficient number of radiologists, the demand remains high in states in the North and Northeast as well as rural cities, which often lack radiologists. The average salary of a diagnostic radiologist in Brazil is 313,000 BRL/year (\$62,758/year) (47).

Physicians have the opportunity to work in either the public or private sector. They can also engage in dual practice. More than half of Brazilian physicians engage in dual practice, while one fifth are employed only as public practitioners (48). Those who work exclusively in private practice or hold dual roles often get paid higher salaries and tend to hold a specialization. Distribution of physicians who work in the private sector or dual roles varies by region as well. The Northeast region has a high prevalence of physicians working only as public practitioners, while the Central-West region has a large proportion of dual and private practitioners (48).

Radiologic technology

A radiologic technology associate's degree can be obtained with a three year program. As of 2014, there were 131 radiologic technology programs in the country. The Ministry of Education stated that a student's workload must contain at least 2,400 hours of education in the classroom over the three years (49). The average salary of a radiologic technologist is 113,000 BRL/year (\$22,657/year) (50).

Visiting Brazil

Spoken languages

The official language of Brazil is Portuguese, making it the most populous Portuguese-speaking country in the world. However, numerous indigenous languages are also

spoken, including Nheengatu and Terena (51). There are approximately 228 (217 indigenous and 11 non-indigenous) languages spoken in Brazil (51).

Education

Primary education (elementary school) consists of grades 1–9 for students of ages 6 to 14 years; primary education is compulsory for citizens between the ages of 7 and 14. Secondary education (high school) is from grades 10 to 12 for students 15 to 18 years of age. Tertiary education (e.g., undergraduate, graduate, and doctoral education) varies in length. Portuguese is the medium of instruction, but foreign languages, including English, are taught later in the students' primary education. English tends to be a core subject in secondary education as well (52). Brazil spends approximately 6% of its gross domestic product on education each year. This is more than the average 5.5% spent by the countries of the Organization for Economic Cooperation and Development (OECD) (53). The Programme for International Student Assessment is administered every three years by the OECD and partner countries (such as Brazil) to measure school performance of 15-year-old students. Although the performance of students in Brazil has improved since 2003, it ranked below the OECD average in reading, mathematics, and science in 2018 (54). In the 2018 assessment, students who were socioeconomically advantaged outperformed disadvantaged students in reading by 97 score points, close to the 89-score-point difference between classes among OECD nations. However, 10% of disadvantaged students in Brazil scored in the top quarter for reading performance within Brazil (54).

Local safety

Brazil is considered safe for tourists; however, there should be heightened awareness when traveling alone, particularly at night. Violent crime is not an uncommon occurrence in urban areas, especially at night. It is recommended that visitors avoid traveling at night, avoid wearing expensive jewelry when alone, and be highly vigilant of their surroundings. The US Department of State currently has a level 2 travel advisory (exercise increased caution) for travelers to Brazil because of crime (55). There is a level 4 (do not travel) warning to within 100 miles of the land borders with Venezuela, Colombia, Peru, Bolivia, Guyana, Suriname, French Guiana, and Paraguay, also because of crime. Favelas, a kind of slum in Brazil, are dispersed throughout the country. There is a level 4 travel warning to favelas as well because the security situation is unknown or nonexistent (55).

Health advisories

The Centers for Disease Control and Prevention recommends that all travelers be up-to-date on all routine vaccinations, including those for varicella, diphtheria/tetanus/pertussis, measles/mumps/rubella, and shingles (56). It is also recommended that travelers of age one year or older be vaccinated for hepatitis A. Although the Yellow fever vaccine is not mandatory for travelers, it is recommended for travelers ≥ 9 months of age going to certain areas, including the states

of Rio de Janeiro, Minas Gerais, and Mato Grosso. Typhoid vaccination is also recommended for most travelers. Rabid dogs are not uncommon in Brazil; however, vaccination for rabies is only considered if tourists expect to interact with wildlife (56). Rabies treatment is widely available in Brazil. Everyone is advised to avoid tap and well water and to drink only bottled water.

Malaria transmission is high in some areas of Brazil, particularly in the states of Acre, Amapá, Amazonas, Rondônia, and Roraima. *Plasmodium vivax* accounts for 90% of malaria cases, whereas *Plasmodium falciparum* accounts for the remaining 10% (57). *P. falciparum* has resistance to chloroquine, but chemoprophylaxis can be achieved with atovaquone-proguanil, mefloquine, or doxycycline (57).

Most health insurance plans in the United States do not cover travelers to Brazil, but travel medical insurance can be bought for one's trip. Although local health insurance is not required for travelers to Brazil, it is important to know about local emergency departments, hospitals, and clinics should they be needed. Visitors should bring a list of all medications they take and notify practitioners of any chronic conditions and allergies they have when receiving care (56).

Climate/when to visit

Summer in Brazil lasts from December to April, whereas winter is from June to October. There is a short fall season after March and a brief spring after September. The climate varies depending on the region. The Northeast is warm year-round, and the Amazon is humid year-round. The Southeast region of Brazil tends to be very hot in the summer and milder in the winter. Summers tend to be very hot, with temperatures sometimes rising to 43°C (110°F) (58).

December through March is a popular time for tourists to visit but is also a time of higher flight and accommodation prices. With the warmer weather, people are able to spend more time outdoors and experience the various cultural attractions that the country has to offer. Many may prefer to go during the winter months of July and August when travel is more affordable and less busy.

Power supply

The Sistema Interligado Nacional is an electricity grid that connects several regions throughout the country (59). While a majority of the country is connected to this system, there is a small percentage outside of this grid, mainly located in the north. The electricity capacity in the Sistema Interligado Nacional is approximately 175,878 MW (60), and 100% of the population has access to electricity (61). Electricity generation in the country is dominated by renewable energy: hydropower is responsible for 62% of production, and wind and solar power generation together account for 15% (60). Brazil has two nuclear reactors that contribute to 3% of the country's electricity generation (62).

Most of the hydropower capacity comes from the Amazon and Tocantins River Basin, but demand is highest in the south of the country. The long distance between the supply and demand areas and the occurrence of drought result in vulnerability to power supply shortages (63). Hospitals require consistent power supply, and power supply disruptions can render medical devices unusable. Centro Hospitalar São Camilo in Ponta Grossa, Paraná, worked with Hitachi Energy to address this. In 2021, two power quality filters were installed to help detect and fix disruptions in power supply (64).

The Brazilian Electricity Regulatory Agency regulates the generation, transmission, and distribution of electricity (65). Electricity costs are approximately 0.749 BRL/kWh (\$0.156/kWh) for households and 0.759 BRL/kWh (\$0.159/kWh) for businesses (66).

Internet

Approximately 76% of Brazil's population has access to the internet (67). As of April 2022, data from the Speedtest Global Index rank Brazil 79th in mobile download speed at 22.73 Mbps and 35th in fixed broadband download speed at 91.82 Mbps (68) (Table 6).

Table 6. Median internet speeds among major Latin American countries.*

Country	Internet speed (Mbps)			
	Mobile		Fixed broadband	
	Download	Upload	Download	Upload
Brazil	22.73	8.13	91.82	48.34
Mexico	26.30	9.41	43.05	11.25
Chile	22.35	11.17	200.01	95.79
Argentina	20.94	6.86	43.04	18.05
Colombia	11.55	8.69	73.04	23.29

*Data as of April 2022 (68).

Data from Speedtest Intelligence show that Claro provides the fastest mobile download and upload speeds, and Vivo had the fastest fixed broadband download (68.25 Mbps) and upload (52.72 Mbps) speeds (69). Average internet speeds also vary among cities (Table 7).

Average monthly costs for internet access are around 95.50 BRL (\$20) in São Paulo (70) and 105 BRL (\$22) in Rio de Janeiro (71). The Brazilian internet access market had a revenue of \$7.7 billion in 2020 (72). Brazil accounts for 8.3% of the internet access market in the Americas, whereas the United States accounts for 70.8% (72). Fiber optic service is the largest segment of the internet access market (44%), whereas cable service accounts for 25% (72).

Table 7. Median mobile internet speeds among major Brazilian cities.*

City	Download (Mbps)	Upload (Mbps)
Brasília	31.88	11.23
Curitiba	30.01	8.91
São Paulo	26.83	8.86
Rio de Janeiro	26.37	9.25
Salvador	25.03	9.45

*Data as of April 2022 (69).

Travel access

Brazil has around 2,500 airports, 33 of which are international hubs. São Paulo Guarulhos International Airport is considered the busiest airport in Brazil and the main international airport (73). Travelers from the United States to Brazil go through international airports, Miami International Airport being the most popular, followed by George Bush Intercontinental Airport in Houston, Texas, and John F. Kennedy International Airport in New York City (74). The total flight time from the United States to Brazil is approximately nine hours based on a distance of 4,273 miles (75).

Travel to Brazil from the United States requires a valid passport and at least one blank passport page for entry stamp (55). In 2018, an eVisa system was launched for travelers from the United States, Canada, Australia, and Japan to apply for a visa online. In 2019, the Brazilian government removed the visitor visa requirement for passport holders from these four countries. In early 2023, the Brazilian government stated that it was renewing the visitor visa requirements for the aforementioned four countries starting on October 1, 2023. Visitors from these four countries would be able to utilize the eVisa system (76).

Local currency

The currency of Brazil is the Brazilian real (BRL). Travelers with more than 10,000 BRL must declare their currency to customs for entry to and exit from Brazil (55). Although many tourists use credit cards to pay for things in Brazil, it is helpful to have some hard currency on hand. There are several money exchange centers and major banks in Brazil that conduct currency exchange.

Accommodations

There are many hotels in Brazil with ratings ranging from 1 star to 5 stars. There are also options for tourists to rent apartments for short stays and share a hostel unit. The average price of a hotel ranges from 184 BRL/night (\$36/night) to 930 BRL/night (\$182/night), with the price depending on the number of hotel stars, location, and type of room (77).

Culture and local attractions

Brazil's culture can largely be traced back to the centuries it was a colony of Portugal. Approximately 65% of the population is Roman Catholic, whereas 22% affiliate with a Protestant faith (78).

Brazilian cuisine is a mix of influences from Asia, Europe, and Africa. Rice and beans are some of the main items. Feijoada (beans, beef, and pork stew), coxinha (chicken wrapped in dough), and pastel (pastry crust containing various fillings, such as cheese) are popular among the population (79).

Brazil celebrates some major holidays, notably Tiradentes Day, celebrated on April 21st, honoring Joaquim José da Silva Xavier, a member of a revolutionary movement to achieve independence from the Portuguese colonial power and create an independent republic. Independence Day is celebrated on September 7th (79).

There are scores of beautiful attractions throughout Brazil. Tourists often utilize one of dozens of tour agencies, and tour guides are often multilingual. Various travel agencies are available that pick patrons up from their respective hotels and takes them to various cultural attractions, often traveling by bus or van. Famous attractions that tourists visit include Christ the Redeemer and Sugarloaf Mountain in Rio de Janeiro. Brazil is home to the Maracanã stadium as well. Located in Rio de Janeiro, it was home to the 1950 and 2014 FIFA World Cup tournaments (80).

The Cathedral of Brasília and Iguazu Falls, located on the border of Brazil and Argentina, are also popular attractions. Those who want to see wildlife can visit Pantanal, the world's largest wetland, which is located in the west of the country, crossing into Bolivia and Paraguay (81). Carnival is a huge Brazilian festival held annually before the start of Lent involving samba dancing, parades, and music and often draws massive crowds. The Sambadrome, located in Rio de Janeiro, is a venue built specifically for the yearly event.

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Conflicts of Interest

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