



COUNTRY SITUATIONAL ANALYSIS

Brazil is in the east of South America. The largest cities, including São Paulo and Rio de Janeiro, are located on the Atlantic coast, although inland cities have experienced significant growth. Endemic foci of sylvatic yellow fever (YF) transmission generally persist in the Amazon Region. The virus occasionally spreads to other regions (Northeast, Midwest, Southeast, and South) when outbreaks of sylvatic YF are recorded. As a result, the YF vaccination recommendation was updated in 2019 to include the entire territory. YF viral transmission is exclusively sylvatic in Brazil. The last evidence of urban transmission was in 1942. However, sylvatic transmission around urban centers in recent years has raised concern about the risk of re-emergence. Since the reintroduction of *Aedes aegypti*, dengue has become a primary public health problem, with steady increases in both incidence and geographical extension. In addition, three other arboviruses have been introduced in recent decades: West Nile virus, Chikungunya, and Zika. The dramatic spread of these diseases, and their associated morbidity, demonstrate their extraordinary capacity to invade a primarily susceptible population.

ECOLOGICAL FACTORS AND CLIMATE¹

Brazil is almost entirely tropical. Different ecoregions converge in the country:

- 1) The **Amazon**, the largest forest on the planet, occupies over 50% of the country's territory. It is crossed by the Amazon River and its tributaries. It is a tropical rainforest with high biodiversity.
- 2) **Mata** or **Atlantic Forest**: tropical forest in the coastal region that extends southwest. Most of the population lives in this region.
- 3) **Cerrado**: a tropical savannah south of the Amazon, occupying 22% of the territory, in the center of the country.
- 4) **Caatinga**: occupies 11% of the country in the northeast. It is a subtropical ecosystem with a semi-arid climate.
- 5) **Pampa**: tropical savannah south of the Amazon, in the center of the country, which occupies 22% of the territory.
- 6) **Pantanal**: a humid plain that floods during the rainy season, with high biodiversity. It occupies less than 2% of the territory to the west, on the border with Bolivia (Plurinational State of) and Paraguay. Forest areas make up 60% of land cover, with 28% used for agricultural purposes.

Vector distribution and incidence

Data on sylvatic vectors are collected when investigating suspected events. During the recent re-emergence (2014–2022), the primary vector associated with transmission was the *Haemagogus* mosquito while the *Sabethes* genus was more local or secondary. *Aedes albopictus* mosquitos naturally infected with the YF virus have been reported in Minas Gerais, Rio de Janeiro, and São Paulo.

YELLOW FEVER HIGHLIGHTS

EYE strategy risk categorization	High
Routine immunization introduced (year)	1994
Latest official coverage estimates (2021)	58%
GAVI eligibility	No
International Coordinating Group on vaccine provision requests	No
Last disruptive yellow fever outbreak	2017-2019
Yellow fever vaccination proof for entry/exit	No
Diagnostic capacity	Yes
Fragility, conflict, and violence status	No

DEMOGRAPHICS²

Total population	211 049 519
Annual population growth rate	0,7%
Life expectancy	80 years (female) and 72 years (male)
Percentage population living in urban dwelling	87%
Percentage urban population living in slums	16%

¹ World Bank. Climate Change Knowledge Portal for Development Practitioners and Policy Makers: Brazil. Washington (DC): World Bank; 2021. Available from: <https://climateknowledgeportal.worldbank.org/country/brazil>

² World Bank. Understanding poverty: Open data. Washington (DC): World Bank; 2020. Available from: <https://www.worldbank.org/en/understanding-poverty>

However, the viral load was low, possibly indicating accidental infection, and its involvement in the transmission of the virus to humans has not been established.³

Brazil collects data on *Aedes aegypti* at least four times a year to calculate infestation rates according to the guidelines of the National Dengue Control Program. *Aedes aegypti* is widely distributed in the country.

EPIDEMIOLOGY

Urban yellow fever affected major port cities of northeastern Brazil during the 17th and 18th centuries. In the mid-19th century, epidemics reached the southeast of the country, with an outbreak in Rio de Janeiro that left more than 4000 dead. With the successful introduction of the YF vaccine and the campaign to eradicate *Aedes aegypti* in the hemisphere, urban outbreaks disappeared, with the last urban cases reported in Acre (north Brazil) in 1942. In 1958, Brazil was declared free of *Aedes aegypti* by PAHO. Since then, only cases related to sylvatic transmission have been reported, usually preceded by epizootic activity in non-human primates. Over a decade after its elimination, re-infestation of *Ae. aegypti* posed a new public health threat: dengue and the risk of a re-emergence of urban YF. YF cases have an annual incidence with outbreaks of varying magnitude at irregular intervals. The disease shows a seasonal pattern, with two periods: higher transmission between December to May and lower transmission between June and November. In the 21st century, viral activity spread beyond its endemic area in the Amazon into the Midwest, Southeast, and South, and with a lower incidence to the Northeast. The largest sylvatic YF outbreak in the country began in 2014 in the Midwest region, with an epicenter in the Southeast during 2017 and 2018. This threatened metropolitan areas of large cities such as São Paulo and Rio de Janeiro, which are home to a vast unvaccinated population.

Between 1960 and 2021, Brazil reported 3838 cases of YF and 1156 deaths to PAHO. More than half correspond to the period 2016-2019, with an average case fatality rate of 30.1%. There were no urban transmission events. Eighty-one percent were males of an economically active age and more than 63% were involved in agricultural and forestry activities.

Endemic areas

The Amazon region is considered endemic. However, vaccination is recommended across the entire country due to the high risk of YF outbreaks when the virus reemerges outside the endemic area, including the Atlantic Forest near the large metropolitan areas of the Southeast.

PAST OUTBREAKS⁴

Year	Number	Region	Comments
1964-1966	42	Midwest (GO, MS), Southeast (MG), and South (PR, SC, RS)	Reemergence of the YF virus outside the Amazon Region (endemic). Historical count of cases available in the archives of the Ministry of Health.
1972-1974	74	Northeast (MA), Midwest (GO, MS), and Southeast (MG)	Reemergence of the YF virus outside the Amazon Region (endemic). Historical count of cases available in the archives of the Ministry of Health.
1977-1982	61	Northeast (MA), Midwest (GO, MS), and Southeast (MG)	Reemergence of the YF virus outside the Amazon Region (endemic). Of the total cases, 46 (75.4%) were men. The number of deaths associated with the outbreak was 55 (case fatality rate: 90.2%). The higher case fatality rate is due to the surveillance strategy at the time, which was based on the detection of areas with cases rather than of all cases of the disease. In addition, most of the diagnosis was made by viscerotomy. ⁵
1986-1996	157	Northeast (MA), Midwest (GO, MS), and Southeast (MG)	After a period in which transmission was restricted to the endemic area, the YF virus re-emerged outside the Amazon Region. Of the cases, 104 (66.2%) were men. The number of reported deaths associated with this outbreak was 58 (case fatality rate: 36.9%). The state of Maranhão reported 57.3% (90/157) of the cases in humans.

3 Pinheiro GG, Rocha MN, de Oliveira MA, Moreira LA, Andrade Filho JD. Detection of Yellow Fever Virus in Sylvatic Mosquitoes during Disease Outbreaks of 2017–2018 in Minas Gerais State, Brazil. *Insects*. 2019;10(5):136. Available from: <https://doi.org/10.3390/insects10050136>

4 Pan American Health Organization. Epidemiological alerts and updates. Washington, DC: PAHO; n.d. Available from: <https://www.paho.org/en/epidemiological-alerts-and-updates>

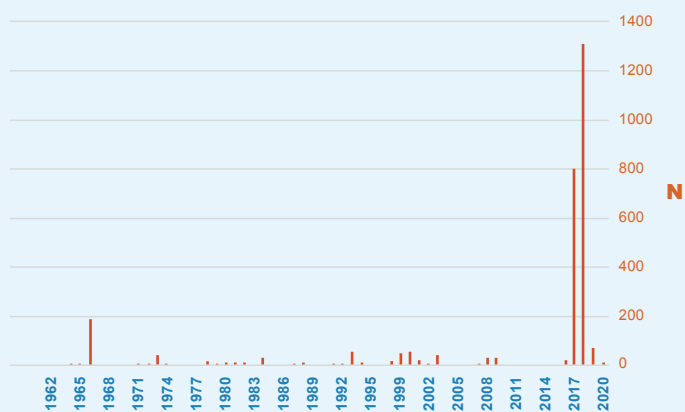
5 Costa ZGA, Romano APM, Elkhoury ANM, Flannery B. Evolução histórica da vigilância epidemiológica e do controle da febre amarela no Brasil. *Rev Pan-Amaz Saude*. <http://scielo.iec.gov.br/pdf/rpas/v2n1/v2n1a02.pdf>

1999-2003	199	Northeast (BA), Midwest (GO, DF) and Southeast (MG, SP)	The virus re-emerged outside the Amazon Region after detection of human cases in the endemic area. Among the cases, 166 (83.4%) were male; 86 deaths associated with this outbreak were reported (case fatality rate: 43.2%). Surveillance of non-human primates in Brazil began in 1999. During the period, 11 laboratory epizootics were confirmed in non-human primates (GO, MG, RS). ⁶
2007-2010	95	Midwest (GO, DF, MS), Southeast (MG, SP), and South (PR, RS)	Re-emergence of the YF virus outside the Amazon Region, after viral activity in the endemic area. Of the cases, 69 (72.6%) were male. A total of 46 deaths (case fatality rate: 48.4%) associated with this outbreak were reported. During the period, 233 laboratory epizootics were confirmed in non-human primates (TO, GO, DF, MS, MG, RS). This was the first detection of the YF virus in the South in 40 years. ⁷ A new lineage of the virus was described. ⁸
2015-2022	2289	North (TO), Midwest (GO, DF, MS), Southeast (MG, SP, ES, RJ), and South (PR, SC, RS)	Reemergence of the virus outside the Amazon Region in 2014, after viral activity in the endemic area. Of the cases, 1889 (82.5%) were male.; 780 deaths associated with this outbreak were reported (case fatality rate: 34%). During the period, 2159 epizootics in non-human primates were laboratory-confirmed (AC, PA, RO, RR, TO, GO, DF, MT, BA, MG, SP, ES, RJ, PR, SC, RS). ^{9,10,11} Different lineages of YF virus were detected co-circulating outside the Amazon region during re-emergence. ¹² Recent transmission in the Midwest has been shown to be caused by a lineage different from that which caused the outbreaks in the Southeast and South. ¹³

Trends of previous outbreaks¹⁴

The YF epidemiological scenario in Brazil is dynamic. In recent years, major trends have been reversed, culminating in the largest sylvatic YF outbreak the country and region have ever experienced. Transmission spread from the endemic area (Amazon/North region) to the Midwest, and then to the Southeast and South, affecting new areas that had not reported cases for decades and were considered low risk during previous risk assessments. The epicenter of the last outbreak (2017-2019) was the southeastern and southern states. The cases in humans were preceded by an expanding area of sentinel epizootics, driven by the displacement of the virus through sylvatic corridors. During this outbreak (2014-2022), Brazil reported 2289 cases and 780 deaths (case fatality rate: 34%), values that in eight years exceeded the total reported by the country for the period 1960-2013.

Number of yellow fever cases in Brazil, 1962-2020



6 Brazil. Ministry of Health. Secretariat of Health Surveillance. Departamento de Análise em Saúde e Vigilância de Doenças não Transmissíveis. Saúde Brasil 2020/2021: uma análise da situação de saúde e da qualidade da informação. [Internet]. Brasília: Ministry of Health, 2021. Available from: <http://svs.aids.gov.br/dantps/centrais-de-conteudos/publicacoes/saude-brasil/saude-brasil-2020-2021.pdf>

7 Ibid.

8 de Souza RP, Foster PG, Sallum MA, Coimbra TL, Maeda AY, Silveira VR, et al. Detection of a new yellow fever virus lineage within the South American genotype I in Brazil. J Med Virol. 2010 Jan;82(1):175-85. Available from: doi.org/10.1002/JMV.21606

9 See Note 6.

10 Brazil. Brazil Ministry of Health, Secretariat of Health Surveillance. Monitoring two cases of urban arboviruses caused by viruses transmitted by Aedes mosquito (dengue, chikungunya, and Zika), epidemiological weeks 1 to 33, 2021; Vigilância epidemiológica do sarampo no Brasil – epidemiological weeks 1 to 31, 2021; Situação epidemiológica da febre amarela: monitoramento 2020/2021. Epidemiological bulletin, vol. 52, no. 31, August 2021. Brasília: Ministry of Health; 2021. Available from: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/boletins/boletins-epidemiologicos/edicoes/2021/boletim_epidemiologico_svs_31.pdf/view

11 Brazil. Ministry of Health, State Health Surveillance Center, Epidemiological Surveillance Division. Schilling Ranieri TM. Technical Note CGARB/DEIDT/SVS/MS no. 3/2022: Informa sobre as áreas com transmissão de Febre Amarela e a importância da intensificação das ações de vacinação e de vigilância nas áreas afetadas e ampliadas, April 26, 2021. Porto Alegre: CEV

12 Delatorre E, Vieira Santos de Abreu F, Pereira Ribeiro I, Martínez Gómez M, Araújo Cunha do Santos A, Ferreira-de-Brito A, et al. Distinct YFV Lineages Co-circulated in the Central-Western and Southeastern Brazilian Regions From 2015 to 2018. 24 May 2019 Front. Microbiol., 10. Available from: <https://doi.org/10.3389/fmicb.2019.01079>

13 See Note 10

14 See Note 4.

Serosurveys

A YF serosurvey in 581 people living in a YF risk area in the state of Minas Gerais found 25.8% of people lacking YF neutralizing antibodies. In addition, no neutralizing antibodies were detected in 10 individuals with confirmed vaccination.¹⁵

In Goiás, a serosurvey found a high frequency (97.6%) of protective titers (>1:10) of YF-neutralizing antibodies; the frequency of titers of 1:640 or higher was 23.2%, indicating broad immune protection against disease in the study population. The presence of protective immunity correlated with increasing age.¹⁶

ARBOVIRAL ACTIVITY

Dengue Dengue outbreaks in Brazil began in the early 1980s and since then, both the incidence and geographical dispersion have continued to increase, with the co-circulation of serotypes. Brazil is the country that reports the highest number of dengue cases in the Region. The estimate for the 1982-2021 period is over 18 million cases.¹⁷

Chikungunya Chikungunya virus disease emerged in Brazil in 2014 and has since spread throughout the country and the Region. During the period 2013-2017, the country reported over 773 000 cases to PAHO.¹⁸

Zika Cases of Zika fever appeared in Brazil in early 2015, but phylogenetic analyses of viral genomes suggest that the Zika virus had been present since 2013 or 2014. Brazil reported a total of 231 725 cases between 2015 and 2017, and 2952 confirmed zika-associated birth defects¹⁹. Non-human primates infected with the Zika virus were reported in the Northeast of the country.²⁰

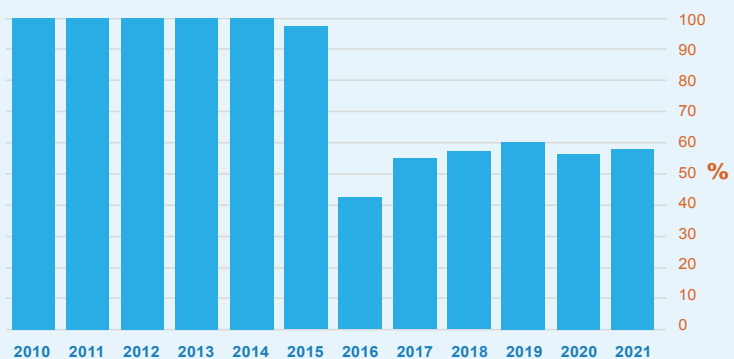
YELLOW FEVER VACCINATION

Routine childhood immunization²¹

Yellow fever vaccine introduced	Yes
Level	National
Year of introduction	1999
Age vaccine is administered (months)	Nine
Vaccine schedule	Two doses
Integration with first does of measles, mumps, rubella vaccine (MMR-1)	No

Vaccination coverage²²

Childhood yellow fever vaccination coverage in Brazil, 2010-2021 (%)



During 2016-2018, Brazil updated its immunization policies increasing the recommended vaccination zone to cover the entire country as of 2019. This is reflected in the general decline in yellow fever vaccination coverage, as implementation is still underway.

The increased gap between MMR-1 and YF vaccination observed since 2016 following this recommendation is gradually narrowing.

Vaccination campaigns²³

Catch-up campaigns implemented during the last 20 years	Yes
Preventive mass campaigns implemented during the last 20 years	Yes
Reactive vaccination campaigns implemented during the last 20 years	Yes

15 Stoffella-Dutra AG, Silva de Oliveira J, Barbosa Costa G, Geessien Kroon E, Santos Abrahão J. et al. Absence of YF-neutralizing antibodies in vulnerable populations of Brazil: A warning for epidemiological surveillance and the potential risks for future outbreaks. *Vaccine*. 2020 Sep 29;38(42):6592-6599. <https://doi.org/10.1016/j.vaccine.2020.07.077>

16 Machado VW, da Costa Vasconcelos PF, Vieira Pinto Silva E, Barberino Santos J. Serologic assessment of yellow fever immunity in the rural population of a yellow fever-endemic area in Central Brazil. *Rev Soc Bras Med Trop*. 2013 Mar-Apr;46(2):166-71. Available from: <https://doi.org/10.1590/0037-8682-0007-2012>

17 Pan American Health Organization. Health Information Platform for the Americas (PLISA). Dengue and severe dengue: Cases and deaths for the countries and territories of the Americas. Washington, DC: PAHO; n.d. Available from: <https://www3.paho.org/data/index.php/es/temas/indicadores-dengue/dengue-nacional/237-dengue-casos-muertes-pais-ano.html>

18 Pan American Health Organization. Chikungunya. Data and statistics. Cumulative number of confirmed cases of Chikungunya in South America from 2013 to 2017. Washington, DC: PAHO; n.d. Available from: <https://www.paho.org/en/topics/chikungunya>

19 Pan American Health Organization. Zika cases and congenital syndrome associated with Zika virus reported by countries and territories in the Americas, 2015-2018. Cumulative cases. Washington, D.C.: PAHO; 2018. Available from: <https://www.paho.org/en/topics/zika>

20 Favoretto S, Araújo D, Oliveira D, Duarte N, Mesquita F, Zanotto P et al. First detection of Zika virus in neotropical primates in Brazil: a possible new reservoir. *bioRxiv* [Preprint]. 2016. Available from: <https://www.biorxiv.org/content/10.1101/049395v1>

21 Pan American Health Organization. Comprehensive Family Immunization Unit. Survey for mapping of national policies on yellow fever vaccination and their implementation. Washington, DC: PAHO; Unpublished.

22 World Health Organization. Immunization data Yellow fever vaccination coverage Geneva: WHO; n.d. Available from: <https://immunizationdata.who.int/pages/coverage/yfv.html>

23 See Note 21.

January-May 2017	To intensify the selective vaccination strategy, 23.02 million YF vaccine doses were distributed to 2085 municipalities in the states of Bahia, Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo. Administrative coverage of 95% or above was achieved in 1208 municipalities; coverage was between 75% and 94.9% in 407 municipalities, and less than 75% in 470 municipalities of which 132 had a coverage of less than 50%. In line with WHO guidelines, in April 2017 Brazil adopted a single-dose YF vaccination schedule.		
February to March 2018	To prevent a major YF outbreak, the Ministry of Health rolled out a mass vaccination campaign, which included both standard (0.5 ml) and fractionated (0.1 ml) doses. This was carried out between February and March 2018 in the states of Bahia, Rio de Janeiro, and São Paulo, and aimed to vaccinate 19.7 million people (15 million with the fractional dose and 4.7 million with the standard dose) living in 77 municipalities of these three states. In addition, the vaccination schedule was changed from two doses in children under 5 years of age and a booster after the age of 5 to a single-dose schedule from 9 months of age. The use of fractional doses to respond to outbreaks, especially in large cities, has also been adopted. This strategy was implemented in Bahia, São Paulo, and Rio de Janeiro. By 2018, the results of this mass campaign indicate that 13.3 million people were vaccinated in São Paulo, 6.5 million in Rio de Janeiro, and 1.85 million in the Bahia state, representing a vaccination coverage of 53.6%, 55.6%, and 55.0%, respectively.		
Vaccination in international travelers²⁴		Yes	
Brazil provides the YF vaccine to travelers arriving from or departing for at-risk countries.			
Vaccination in internal travelers (when traveling to high-risk areas in the country)?		Yes	
Brazil provides the YF vaccine to travelers arriving from or departing for endemic or at-risk states. The Ministry of Health recommendation is that travelers to endemic or at-risk areas be vaccinated at least 10 days before traveling.			
Registration system to record vaccination data²⁵		Electronic immunization registry system	
Vaccine program funding²⁶			
Sources of funding		Government	
Gaps in funding during the past 5 years?		No	
Does the country require financial support?		No	
INTERNATIONAL HEALTH REGULATIONS²⁷			
Does the country request proof of yellow fever vaccination at points of entry?		No	
LABORATORY DIAGNOSTIC CAPACITY²⁸		SURVEILLANCE²⁹	
Member of the Arbovirus Diagnostic Laboratory Network of the Americas	Yes	National guidelines for surveillance	Yes

²⁴ Ibid.

²⁵ Ibid.

²⁶ Ibid.

²⁷ Ibid.

²⁸ Ibid.

²⁹ Ibid.

National Reference Laboratories	Evandro Chagas Institute, Pará; Fiocruz Foundation, Rio de Janeiro; Fiocruz Foundation, Paraná; Fiocruz Foundation, Pernambuco; Adolfo Lutz Institute, São Paulo, and Ezequiel Dias Foundation, Minas Gerais.	Evandro Chagas Institute, Pará; Fiocruz Foundation, Rio de Janeiro; Fiocruz Foundation, Paraná; Fiocruz Foundation, Pernambuco; Adolfo Lutz Institute, São Paulo, and Ezequiel Dias Foundation, Minas Gerais.	
Reports to PAHO	Yes	Type of surveillance for non-human primates Passive and active	
TESTING CAPACITY FOR YELLOW FEVER		Urban vectors Yes	
		Sylvatic vectors (outbreak investigation) Yes	
IgM antibody capture enzyme-linked immunosorbent assay (MAC-ELISA)	Yes	Entomological surveillance Yes	
		Entomovirological surveillance Yes	
Plaque reduction neutralization tests (PRNT)	Yes	Case investigation (reactive) Yes	
Reverse transcription polymerase chain reaction (RT-PCR) blood specimens	Yes	YELLOW FEVER CONTROL STRATEGIES	
RT-PCR tissue specimens	Yes	Multi-annual immunization plan Yes	
RT-PCR wild type virus versus vaccine	Yes	Risk assessment methodology ³⁰ Yes	
Immunohistochemistry	Yes	Vector control activities Yes	
Virus isolation	Yes	Diagnosis Yes	
External Quality Assessment compliance	Yes	Surveillance Yes	
Shortages of diagnostic supplies in the last 5 years?	No	Request for proof of YF vaccination at points of entry No	

POPULATION MOVEMENTS³¹

A mass migratory influx on the border with Venezuela prompted Brazil to host Venezuelan citizens for humanitarian reasons. An estimated 260 000 Venezuelan migrants live in Brazil, with more than 46 000 with refugee status. YF vaccination is offered to migrants arriving in and leaving the country.

³⁰ The country has its own risk assessment methodology, based on epidemiological, environmental, and climatic factors related to the transmission of the virus.

³¹ Office of the United Nations High Commissioner for Refugees (UNHCR). UNHCR Data. Geneva: UNHCR; s. f. Available from: <https://www.unhcr.org/en-us/data.html>