Review

APPROACHES ON SANITATION AND HEALTH IN THE LEGAL AMAZON: A LITERATURE REVIEW (2013-2023).

ABORDAGENS SOBRE SANEAMENTO E SAÚDE NA AMAZÔNIA LEGAL: UMA REVISÃO DE LITERATURA (2013-2023).

Regina Célia Borges Lucena[1], Marcílio Sandro Medeiros[2].

[1] Agência Nacional de Vigilância Sanitária, Brasília, Brasil. e-mail: regina.lucena@anvisa.gov.br
: https://orcid.org/0000-0002-5959-3301

[2] Fundação Oswaldo Cruz – Instituto Leônidas e Maria Deane – Laboratório Território, Ambiente, Saúde e Sustentabilidade, Manaus, Brasil. e-mail: marcilio.medeiros@fiocruz.br
: https://orcid.org/0000-0001-9226-7973

Recebido em 11/04/2024 e aceito em 23/09/2024

ABSTRACT: The objective of this article is to understand and analyze the approaches employed in study of the relationship between sanitation and health in the Legal Amazon from 2013 to 2023. This article conducts an integrative review of the literature drawing upon the works available in the Scientific Electronic Library Online, Virtual Health Library, and Capes Periodicals. 64 out of 185 studies are analyzed, in line with the research question and after applying the eligibility criteria. The studies are clustered into four thematic categories: (i) occurrence of diseases and injuries; (ii) environmental analysis, which includes studies on the risks of elements present in the soil, water and animals; (iii) technology assessment and proposal of methodologies; and (iv) impact of capitalist expansion. More than half of the studies (56%) refer to the more classic approach, which establishes a relationship between sanitation conditions and the occurrence of diseases and injuries. At the same time, an expansion of theoretical-conceptual approaches to the topic was identified, including a focus on human rights and environmental justice, especially in studies about the impact of capitalist expansion. The results of this research point to the need of improving the critical reflection on the political, economic, and sociocultural determinants inherent to the connections between sanitation and health in Brazil.

Keywords: Sanitation; Health; Amazon.

RESUMO: O objetivo deste trabalho foi conhecer e analisar as abordagens utilizadas para estudar a relação entre saneamento e saúde na Amazônia Legal na última década, de 2013 a 2023. Trata-se de uma revisão integrativa da literatura, nas bases de dados da *Scientific Electronic Library Online*, Biblioteca Virtual em Saúde e Periódicos Capes. Foram analisados 64 de 185 estudos, de acordo com a questão norteadora e após aplicação dos critérios de elegibilidade. Os estudos foram classificados de acordo com quatro categorias temáticas: (i) ocorrência de doenças e agravos; (ii) análise ambiental, que incluiu os estudos sobre os riscos dos elementos presentes no solo, água e animais; (iii) avaliação de tecnologias e proposição de metodologias; e (iv) impacto da expansão capitalista. Mais da metade dos estudos (56%) se referem à abordagem mais clássica, a que estabelece relação entre as condições de saneamento e a ocorrência de doenças e agravos. Ao mesmo tempo, identificou-se a ampliação dos enfoques teórico-conceituais sobre a temática, inclusive com foco em direitos humanos e justiça ambiental, especialmente nos estudos sobre o impacto da expansão capitalista. A revisão aponta para a necessidade de se avançar na reflexão crítica sobre os determinantes políticos, econômicos e socioculturais inerentes às conexões entre saneamento e saúde no Brasil.

Palavras-chave: Saneamento; Saúde; Amazônia.

INTRODUCTION

The Legal Amazon, legally established as a political territory in Brazil since the 1950s, comprises 772 cities situated across the states of the Northern region (Acre, Amazonas, Amapá, Pará, Rondônia, Roraima, and Tocantins), the state of Mato Grosso in the Center-West region, and partially extending into the state of Maranhão in the Northeastern region. This territory encompasses approximately 59% of Brazil's territory. The Brazilian Amazon is currently a critical part of the global agenda on climate change due to the negative effects from cumulative deforestation and the predatory exploitation of its natural resources throughout the centuries. Besides being one of the most biodiverse regions in the world, the Brazilian Amazon plays an important role as a reservoir of carbon, which has a direct impact on the world's climate (OLIVEIRA et al., 2021).

Adding to these global issues are the enormous local challenges that the Legal Amazon faces regarding access to sanitation and healthcare, due to the insufficiency of public policies aimed at social welfare. Basic sanitation in the Legal Amazon exhibits indicators below the national average: only 60% of households are serviced by a general water supply network compared to the national average of 82,7%. Additionally, sewage collection is only available in 14,6% of households compared to the national average of 38,7% (INFOAMAZONIA, 2024). According to data from the National Research on Basic Sanitation 2017 study, the indicator about households linked to the general sewage system is deficient in practically all Federative Units. However, in 17 states - including all states of the Northern Region - the rates of households served by sewage collection system through the general sewage network range from a meager 9.9% to 54.0% (INHUDES et al. 2022).

The studies aiming to establish connections between access to sanitation services and health conditions in the Legal Amazon are both useful and necessary for understanding the complexity underlying the relationship between inequalities and the quality of life of the affected population, as well as their impacts. However, according to Heller e Gomes (2014), there remains a gap in the Brazilian basic sanitation sector regarding the assessments and qualified critical reflections about the profile of this sector, its shaping forces, its future, and the most adequate public policies to improve it.

The gaps are not only of quantitative nature, but also qualitative, because they include the necessity of curricular changes with regards to the concepts of health, environment and territory in the context of the amazonic communities and peoples (SOUZA e ANDRADE, 2014), as well as the expansion of water and sewage infrastructures as a requirement for mitigating infectious diseases (FERREIRA, SILVA & FIGUEIREDO FILHO, 2021). Therefore, this topic requires addressing the operational challenges related to it and the critical reflection of the object simultaneously. In this sense, the aim of this research is to understand and analyze the approaches employed in previous studies about the relationship between sanitation and health in the Amazon in the last decade, from 2013 to 2023.

MATERIALS AND METHODS

This is an integrative literature review built upon the following research question: what approaches were employed for analyzing the relationship between access to sanitation and health conditions in the Amazon by studies conducted over the past decade?

From this research question, two describers obtained from the portal of Descriptors in Health Sciences (DeCS) were defined and combined by the means of the boolean operator “AND”: Sanitation AND Health AND Amazon.

Literature searches were conducted in the Scielo (Scientific Electronic Library Online), Virtual Health Library (BVS), and Capes Periodicals platform databases, through a sensitive search, regarding studies conducted between 2013 and 2023. The articles were selected initially based on the reading of the abstract, according to the research question and eligibility criteria. The inclusion criteria adopted in this research took into consideration articles written in English, Portuguese, and Spanish.

In addition to duplicate articles, the following were excluded: technical and/or governmental documents; monographs, theses, dissertations; articles without full-text availability; articles that did not correspond to the analysis between sanitation and health; and studies conducted outside the country (in the Peruvian or Bolivian Amazon).

RESULTS AND DISCUSSIONS

185 studies were found, out of which 64 were selected and 121 excluded in line with the research question and eligibility criteria. Based on the complete reading of the selected articles, it was possible to cluster the studies into four thematic categories regarding the relationships identified between sanitation and health: 1) the occurrence of diseases; 2) environmental analysis; 3) evaluation of technologies and proposition of methodologies; and 4) impact of capitalist expansion.

The occurrence of diseases

A significant portion of the studies about the occurrence of diseases focused on acute diarrhea and intestinal parasitosis (Chart 1). According to Inhudes et al. (2022), the number of deaths among the general population and hospitalizations in the population in the age group up to five years of age between 2000 and 2009 in the Amazon is greater than the national average.

Therefore, these diseases are relevant to explain the relationship between health and sanitation in the Region. At the same time, there are studies about other infectious diseases (Chart 2), non-transmissible chronic diseases (Chart 3) and epidemiological profiles (Chart 4). These different themes regarding the occurrence of diseases and injuries converge with the unique aspects of the Brazilian epidemiological transition, which has been defined as a triple burden of diseases, including, at the same time, an

unfinished agenda of infectious, nutritional, and reproductive health diseases, in addition to chronic diseases as well as their external causes (MENDES, 2010).

Chart 1. Category "occurrence of diseases" – intestinal infectious diseases.

DISEASE OR GROUP OF DISEASES	REFERENCE	SUMMARY
Intestinal Parasitosis	ANJOS, B. K. et al., 2018	Profile of intestinal parasitosis and its association with anemia in patients from various municipalities in the interior of Rondônia, based on a retrospective study in a state hospital.
	BALBINO, L. F. et al., 2023	Description of results of parasitological survey regarding the sociodemographic characteristics (including sanitation) of students from the rural school located in the Praia do Amapá neighborhood, in the rural area of the city of Rio Branco in the state of Acre.
	MARQUES, R. C. et al., 2020	Prevalence of intestinal parasitosis and evaluation of hemoglobin levels compared to the nutritional state of children in "riberinha"[1] communities (Itapuã) and mining settlements (Bom Futuro) in Rondônia.
	OLIVEIRA, F. B. et al., 2022	Reporting of results from parasitological surveys regarding sociodemographic characteristics (including sanitation) in rural communities located within extractive reserves in two municipalities of Acre, Xapuri, and Sena Madureira.
	VIEIRA, D. E. A. e BENETTON, M. F. N., 2013	Prevalence of intestinal parasites and identification of environmental and socioeconomic factors involved in the spread of intestinal parasites among users of a health center in Manaus, Amazonas.
Waterborne diseases	ARAÚJO et al., 2021	Correlation between operational indicators of water supply and the frequency of waterborne notifiable diseases (acute diarrheal diseases) in six municipalities of the state of Amapá, Brazil.
	RIEGER, R. A; PENHA, D. L.; TEIXEIRA, E. A., 2021	Analysis of the impact of access to treated water on hospital admissions for waterborne diseases in the Legal Amazon region, through a dynamic econometric panel model.
Diarrhea	IMADA, K. S. et al., 2016	Analysis of the contributions of sanitation actions to the reduction of diarrhea prevalence in the municipality of Jordao, Acre, through two surveys conducted in the years 2005 and 2012.
Soil-transmitted helminthiasis	CALEGAR, D. A. et al., 2021	Description of the epidemiological scenario of soil-transmitted helminthiasis in children from an urban population on Marajo Island, Para.
Helminthiasis and giardiasis	DELFINO, B. M. et al., 2016	Temporal and spatial evolution, between 2003 and 2011, of the socioeconomic and environmental

[1] "Riberinha" refers to riverside communities of native Brazilian origin that often rely on rivers for their livelihoods, transportation, and access to resources.

DISEASE OR GROUP OF DISEASES	REFERENCE	SUMMARY
		determinants of helminthiasis and giardiasis among children in the urban area of Assis Brasil, Acre.

Source: authors.

The infectious diseases studied potentially related to sanitation in the region include, besides diarrhea and intestinal parasitosis, mycoses and other neglected diseases as well as Covid-19 in the most recent analyses (Chart 2).

Chart 2. Category “occurrence of diseases” – infectious and parasitic diseases (non-intestinal).

DISEASE OR GROUP OF DISEASES	REFERENCE	SUMMARY
Malaria-intestinal parasitic co-infection	VASCONCELOS M. P. et al, 2023	Prevalence and impact of coinfection by malaria parasites, helminths, and protozoa in four Yanomami indigenous villages in the Brazilian Amazon rainforest, Amazonas.
Covid-19	COSTA, J. S. et al., 2020	Overview of sanitation in the Brazilian Amazon and its potential impacts on the most vulnerable populations and the healthcare system, in the context of the COVID-19 pandemic, based on literature and documentary review and exploratory analysis of data related to basic sanitation and health.
	GOVEIA, 2020	Analysis of water access in the Brazilian Amazon in relation to the spread of COVID-19, based on data from the Brazilian Institute of Geography and Statistics (IBGE) and the National Information System on Sanitation (SNIS).
Neglected diseases	AGUIAR, E. S. et al., 2023	Spatial and temporal distribution of neglected tropical diseases and their relationship with socio-environmental indicators in the Marajo Archipelago, Paro.
Filariasis	KORTE, R. L. et al., 2013	Identification of possible foci of lymphatic filariasis in Porto Velho and Guajará-Mirim (Rondônia) and Humaitá (Amazonas). The human test was carried out on students from night schools and residents of neighborhoods without sanitation.
Hepatitis	PEREIRA, T. M. et al., 2016	Analysis of the seroprevalence of antibodies against hepatitis A virus (HAV) in children, from 2003 to 2010, as a marker of sanitation and environmental changes in the urban area of Assis Brasil, Acre.
	MANTOVANI, S. A. S. et al., 2015	Analysis of seroprevalence for antibodies against HAV and associated factors in children residing in the urban area of Assis Brasil, Acre, with the

DISEASE OR GROUP OF DISEASES	REFERENCE	SUMMARY
		description of the spatial distribution of seropositive cases and social inequalities.
	VITRAL, C. L. et al., 2014	Epidemiology of human hepatitis A and E, through a multilevel approach to analyze individual and household risk factors, in the Pedro Peixoto settlement, Acre.
	PAULA, V. S. et al., 2020	Prevalence of hepatitis A infection in an indigenous population of the Apinajé ethnicity compared to the urban population, with spatial representation regarding socioeconomic variables.
Malária	MONTEIRO, T. H. A. et al., 2015	Evaluation of basic sanitation indicators and socioeconomic dimensions, characteristics of reported malaria cases, prevalent species of Plasmodium, and classification of the risk level of contracting malaria in the municipality of Ananindeua, Pará.
Mycoses	SILVA, L. C. et al., 2020	Spatial and temporal dynamic of hospitalizations due to mycoses, correlated to the socioeconomic and climatic data in a transition region of Amazon-Savannah in the state of Maranhão.
Tuberculosis	CARDOSO, B. A. et al., 2017	Prevalence of tuberculosis and frequency of latent infection by Mycobacterium tuberculosis, in relation to healthcare coverage, socio-environmental factors, and frequency of intestinal parasite infection, in a district of the municipality of Benevides, Metropolitan Region of Belém, Para;
	GIACOMET, C. L. et al., 2023	Mathematical modeling to assess the influence of structural and intermediary determinants on tuberculosis-related health in Macapá, Amapá.
Tungiasis	SANTANA, Y. R. T. et al., 2023a	Prevalence, intensity, and morbidity of tungiasis in six settlements of the Sanumás community, Yanomami territory in Roraima.
	SANTANA, Y. R. T. et al., 2023b	Evaluation of the effectiveness of topical dimethicone along with a One Health approach (involving animal and environmental measures) for the control of tungiasis, through a real-world cohort study in the indigenous community of Sanumás, Yanomami territory in Roraima, Brazil.

Source: authors.

Furthermore, studies on non-transmissible diseases and their relationship with environmental sanitation in the region are available in Chart 3.

Chart 3. Category “occurrence of diseases” – non-transmissible chronic diseases.

DISEASE	REFERENCE	SUMMARY
Snakebite accidents	SALAZAR, G. K. M. et al., 2021	Analysis of barriers to accessing healthcare for treating snakebite accidents and their relationship with sociodemographic variables in ribeirinha populations of communities located in the municipalities of Amazonas.
	ISAACSON, J. E. et al., 2023	Geospatial analysis of the association between sociodemographic indicators and access to care in cases of snakebite envenomation in Brazil. The North region presented the highest number of cases/population, mortality rates, and proportion of cases that took more than three hours to be detected.
Dental cavity	FRAZÃO, P. et al., 2016.	Occurrence of dental caries and dental care among 12-year-old students in a municipality without fluoridated water: Acrelândia, Acre.
	ALVES FILHO, P.; SANTOS, R. V.; VETTORE, M. V., 2013	Review on the epidemiological profiles of dental caries and their association with the socio-environmental characteristics of indigenous populations in Brazil. The majority of studies (88%) were conducted in the Legal Amazon region.
Nutritional state and food insecurity	GUERRA, L. D. S. et al., 2013	Prevalence of food insecurity and associated factors (demographic and socioeconomic situation) among adolescents in the municipalities of Alta Floresta, Diamantino, Sinop, and Sorriso, Mato Grosso.
	CUNHA, M.P.L.; MARQUES, R.C.; DÓREA, J.G., 2018	Narrative review on the relationship between the nutritional status of children under five years old and environmental factors in the Northern region.
Hypertension e diabetes	SIQUEIRA, J. H. et al., 2023	Prevalence of systemic arterial hypertension or diabetes mellitus, concurrent occurrence, and association with sociodemographic characteristics, lifestyle habits, and access to health services among adults residing in the riverine stretch of the left bank of the Rio Negro, from the municipality of Manaus to the border with the municipality of Novo Airão, Amazonas.

Source: authors.

In addition to studies on the occurrence of specific diseases, groups of diseases, or specific health problems, some analyses aimed to focus on broader perspectives of the relationship between sanitation and health. These studies include the characterization of the overall health and sanitation profile, either in specific populations or in the region as a whole (Chart 4).

Chart 4. Category “occurrence of diseases” – studies about health and sanitation profile.

DISEASE	REFERENCE	SUMMARY
Legal Amazon	VIANA, R. L. et al. 2016	Analysis of the processes for determining the socio-environmental and health situation in the states that make up the Legal Amazon, based on socioeconomic, environmental, and health indicators.
Indigenous population	MARINHO, G. L. et al., 2021	Analysis of the infrastructure related to basic sanitation in urban households within and outside the Legal Amazon, with a focus on indigenous communities. Discussion on the relationship between the results and the health profile of the indigenous population.
Quilombola population	FREITAS, I. G. et al., 2018	Sociodemographic and epidemiological profile of the Quilombola community of Abacatal/Aura, located in the municipality of Ananindeua, RMB, Para.
Rural population	SOUSA, R. S. et al., 2016	Evaluation of water collection and treatment for human consumption, considering the daily sanitation practices carried out by the rural population of the Cumaru stream micro-watershed, in the municipality of Igarape-Açu, Para.

Source: authors.

Environmental analysis

While most studies have focused on analyzing disease burdens, some studies have turned to environmental analysis as an approach to establishing the relationship between environmental sanitation and health in the Amazon. Through the analysis of hosts, soil, and water, these studies have demonstrated the inadequacy of sanitation conditions and the risk to human health from various perspectives.

The presence of potentially toxic elements (PTEs) is a critical issue in the Brazilian Amazon, due to industrial and mining activities and low levels of sanitation and social development, posing risks to human health. Covre et al. (2022) conducted a characterization of the properties of artisanal and industrial copper mining residues, as well as the concentrations of PTEs and potential environmental and human health risks. The analyses were performed on forest soil samples and artisanal/industrial copper mining residues collected in the municipality of Canãa dos Carajás, Pará. Pollution indices showed high copper contamination and moderate chromium and nickel contamination, with non-carcinogenic and carcinogenic risks to human health, especially due to chromium exposure in artisanal rock residues: cardiovascular effects, lung cancer, respiratory arrest, and liver and kidney damage. Another analysis of soil pollution focused on PTEs present in five land uses (a landfill, an alumina refinery area, and three residential centers) in the municipality of Barcarena, Pará (MATOS et al., 2023). The results showed that high levels of PTEs are directly related to sanitation conditions, especially in areas with landfills.

Analyses of freshwater have shown concerning levels of pollution in rivers and major tributaries of the Amazon. These studies indicate the need to improve the sanitation system in urban areas of the Amazon to reduce chemical emissions and their impact on Amazon freshwater ecosystems. Fabregat-Safontre et al. (2021) assessed the occurrence of pharmaceutical products, illicit drugs, and their metabolites in freshwater ecosystems of the Brazilian Amazon. Surface water samples were collected from the Amazon River, three major tributaries (Negro, Tapajós, and Tocantins Rivers), and smaller tributaries and streams crossing urban areas of Manaus, Santarém, Macapá, and Belém. The results showed significant presence of pharmaceuticals in the Amazon River and tributaries, with identification of 51 different compounds and metabolites. Analgesics and antihypertensive medications were commonly found in urban areas, while stimulants such as caffeine or residues of illicit drugs (cocaine) were also found in relatively remote areas. Pereira et al. (2021) investigated the evolution of contamination of the Caeté River estuary by thermotolerant coliforms over the last decade and concluded that water contamination has increased considerably.

Another focus of study is groundwater, whose use is related to insufficient water supply in the region. Queiroz et al. (2022) assessed human health risks associated with consumption of groundwater contaminated with metals around the Marituba landfill, a municipality in the Metropolitan Region of Belem (RMB), Para. In this locality, it was found that the wells constructed in the region are shallow, insufficient, and close to potential contamination sources such as garbage dumps, gas stations, and cemeteries. Groundwater was also the subject of two other studies: Baia et al. (2022), in Porto Velho, Rondônia, whose results showed high fecal contamination of dug and drilled wells; and Meschede et al. (2018), who assessed the quality of drinking water and health implications for schoolchildren in the Santarem region, Para, an area entirely supplied by groundwater. The results of these studies showed biological and/or chemical contamination, posing risks to human health. This reflects the inadequacy of sanitation services and underscores the importance of groundwater protection actions, with consequent improvement in environmental quality and public health.

Host studies also integrated environmental analyses to explain the relationship between health and sanitation in the Amazon. In a study conducted by Moreira et al. (2013), infection by Calodium hepaticum in rodents was demonstrated and quantified in three neighborhoods of the city of Belem, Para, with a lack of public sanitation and high incidence of human leptospirosis. This is a parasite of hepatic parenchyma of rodents and other mammals, including humans, whose presence is associated with inadequate sanitation conditions. According to the authors, confirmation of the presence of C. hepaticum in the studied region reinforces the need for investment in sanitation systems as a measure to control these zoonotic agents. A similar analysis was conducted by Bernal et al. (2021), who assessed the prevalence of antibodies against the hepatitis A virus in captive and free-living wild mammals (non-human primates, carnivores, and didelphids) in three cities in the state of Pará. The results indicated a profile of previous exposure to the hepatitis virus among these animals, and considering the virus transmission route, there is a risk to the human population, especially considering the precarious sanitation conditions. Pantoja et al. (2017)

demonstrated the occurrence of zoonotic enteroparasitoses in coatis (Nasua nasua) in the state of Pará and signaled risks to environmental and human health, considering that these animals can act as sources of infection for humans and other animals.

Borges-Pedro et al. (2018) used the WASH concept (water, sanitation, and hygiene), developed by UNICEF and WHO, to evaluate aspects of the environment of public schools in the municipality of Tefé, Amazonas. Among the findings, the authors found that all schools had total coliform contamination of water and insufficient sanitary facilities. Additionally, some of these schools do not apply any water treatment and have presence of flies and debris accumulation. It was concluded that there is an urgent need for improvements in water, sanitation, and hygiene in the schools of the studied municipality to minimize health risks and improve students' school life.

Jesus et al. (2023) experimentally evaluated the effect of household disinfection measures (2.5% hypochlorite, boiling, ceramic filter, and sunlight exposure), commonly used in the Santarém region, Pará, on the elimination of E. coli in water for human consumption. The results showed that these measures were effective in eliminating E. coli, except for filtration (ceramic). The authors also emphasize that treated water distribution does not reach most of the population residing in the city and peri-urban areas, such as quilombola and riverside communities. Therefore, the use of these measures can contribute to reducing morbidity and mortality from diseases transmitted through this medium, as well as promoting health. Another analysis of water quality in the region concerns the fluoridation of drinking water for public consumption, which must be within established limits for the prevention of dental caries in the population (BANDEIRA et al., 2022). The study showed that about half of the water samples collected in four sanitary districts of Manaus, Amazonas, were outside the recommended parameters for fluoridation. The authors highlight, in addition to the results themselves, problems in the public water supply of the city of Manaus, the uncontrolled growth of the city, and data source inconsistencies.

Although this approach is operationally more related to the environment than to health itself, it is an important indicator of environmental risk in relation to health risks. Elements resulting from environmental parameters regarding water quality, soil, solid waste, among others, allow for adequate environmental monitoring of environmental sanitation conditions and can provide important inputs for public policies in this field.

Assessment of technologies and proposal of methodologies

A third approach, more proactive, concerns the presentation and utilization of technologies and methodologies applied to sanitation, with assessments and inferences about health and recommendations for expanding their use. Five studies of this type have demonstrated the possibility of using interventions to improve the quality of drinking water and indicators or methods capable of assessing health and sanitation conditions in the region, with potential use in defining and directing related public policies.

Ferreira, Luz, and Buss (2016) evaluated the use of simplified diffusion chlorinators as an alternative method of water treatment in the Rural Settlement of Rio Pardo, Presidente Figueiredo, Amazonas. At the time of the initial diagnosis, 100% of the water samples consumed by the population were contaminated with total coliforms and E. coli. The use of chlorinators not only resolved the contamination by thermotolerant coliforms but also achieved a high level of satisfaction in the evaluation of the residents, as it did not impart taste to the drinking water, had relatively low cost, and was easy to handle. Ribeiro, Abreu, and Laporta (2018) also evaluated the simplified chlorinators for the effectiveness of this environmental intervention for water treatment, in a study conducted in rural schools in the municipality of Rio Branco, Acre. The authors concluded that the actions carried out in this intervention improved the water quality of the schools and reduced the sanitary vulnerability in the evaluated school community. A remarkable point is that the success of the intervention was attributed to the comprehensive educational activities that were carried out concurrently.

An evaluation study on the cost-benefit of using a low-cost technology for potable water supply used in various countries, the Sodis system, was conducted by Lobo et al. (2013) in riverside communities in the insular area of Belem (PA). Information gathering was conducted in the field through interviews with residents of households where the Sodis system was implemented, which captures and treats rainwater. The water obtained through the Sodis system did not achieve the expected quality, and the authors attribute this finding to the lack of broad community participation in the planning and implementation stages, leading to a lack of full ownership of the technology by the benefiting families.

A study conducted by Paula et al. (2019) proposed a method based on fuzzy logic for analyzing the risks to the environment and health of sanitary effluents from river passenger vessels in the Amazon Region and water distributed for human consumption on board. Fuzzy logic is based on an extension of value logic, with different objectives and uses, and can associate objective knowledge (numerical data) with subjective knowledge (linguistic information). Risk analysis showed that vessels (regular line between Belém and Santarém) do not have mechanisms for capturing, storing, and treating sanitary effluents and wastewater, releasing them directly into the rivers of the Amazon. Furthermore, the onboard water offered to travelers is of poor quality, with 89% of samples contaminated with total coliforms and 84% with Escherichia coli. Regarding this, the importance of the action of health surveillance and the application of Board Resolution (RDC) No. 72, of December 29, 2009, of the National Health Surveillance Agency (Anvisa), as well as Resolutions of the National Environment Council (Conama) dealing with the management of effluents from vessels, stands out.

Bernardes, Bernardes, and Günther (2018) presented the construction of a household environmental health index focused on rural areas (ISA/DR), which can be used as a tool for diagnosis and evaluation of health-environment conditions in households of riverside communities in the Amazon. Data regarding the environmental and socioeconomic conditions of households were synthesized in the calculation of the ISA/DR from five partial indices: water supply, sewage, solid waste management,

housing condition, and socioeconomic aspects. For feasibility assessment, the ISA/DR was applied in eight riverside communities in the Amazon, located in two sustainable use conservation units, the Middle Juruá Extractive Reserve and the Sustainable Development Reserve, both in the state of Amazonas. The Index proved sensitive to capturing variations in health conditions among households in the studied communities. The authors concluded that it can be used within public policies, including as a guide for priorities for investments and actions in health and environmental health of Brazilian rural households.

Mansur et al. (2016) developed a multicriteria index to measure socioeconomic vulnerability in urban areas of the Amazon Delta and Estuary, which were subdivided into three sectors: small urban spaces in 34 municipalities within and around Marajó Island, Pará; RMB; and the Metropolitan Region of Macapá. The index was applied to classify urban vulnerability based on three dimensions: exposure to floods, socioeconomic sensitivity, and infrastructure. The results indicated that most of the areas studied are exposed to potential risks due to a combination of flood risks, poverty, and basic structural deficiencies, which increase health risks to the population. The study found that vulnerability is exacerbated by factors including the precariousness of urban infrastructure and public services, such as drinking water, domestic effluent and solid waste collection, and drainage systems.

Andrade et al. (2021) developed the multidimensional Extreme Climate Vulnerability Index (IVCE) for the Brazilian Amazon and Northeast regions, as these are the regions that have experienced the most intense and frequent extreme climatic events in the country, i.e., periods of torrential rains and severe droughts. In the index, vulnerability is defined by three components: exposure (extreme climate indicators), susceptibility (sociodemographic indicators), and adaptive capacity (sanitation conditions, urbanization rate, and provision of health care). In this way, it is possible to demonstrate that climatic markers can be applied in the study of population vulnerability. The authors consider that the IVCE is suitable for monitoring this vulnerability over time and can be applied to other areas.

Impact of capitalist expansion

In the last category of this analysis, eight studies address a central theme for understanding the connections between sanitation and health in the Legal Amazon: the mode of economic production. This theme concerns the very place of the Amazon in the context of capitalist accumulation, which is marked, on the one hand, by historically constituted socio-spatial segregation and, on the other hand, by its progressive and predatory incorporation into the logic of capital accumulation (COSTA, 2015). This process of capitalist expansion is marked by the appropriation of the region's natural resources and the generation of intense social inequalities:

> In the specific case of the Amazon, the appropriation of natural resources is drastically exacerbated, as its history is based on the use of natural resources, the absence of coherent and reality-focused policies, largely due to the imposition by capitalists who claim to be responsible for regional dynamism.

> (...) Within this dynamic, the Amazon is inserted into the scenario of the national economy, in such a way that mechanisms for generating profits are established through the predatory use of natural resources facilitated by capitalist expansion. What is worse, traditional populations and migrants succumb to this logic, as they lack the conditions to reproduce more sustainable practices and are incorporated into the logic of least effort reproduction (HERRERA, MOREIRA E BEZERRA, 2016, p. 220).

In this sense, a study analyzed the epidemiological impact of the installation of the Madeira River Hydroelectric Complex on the health of the population of Porto Velho, Rondônia, between 2001 and 2010 (Barcellos et al., 2018). The analysis included a set of health, environmental, and socioeconomic indicators, which constituted markers of the changes that occurred in the human and natural environment compared to the phase before the installation of the hydroelectric projects. The authors observed that there was an increase in the incidence of infectious diseases, such as malaria, AIDS, leishmaniasis, and dengue transmission, related to the implementation of the hydroelectric plants. The context of limited governmental intervention in terms of sanitation and health infrastructure, deforestation, different forms of land use and land cover, as well as migratory processes within the influence area of the hydroelectric plants, is noteworthy.

Gauthier and Moran (2018) analyzed the reasons for non-compliance with legal requirements for water and sanitation in Altamira, Par, due to the construction of the Belo Monte Hydroelectric Plant. The authors reported that the environmental impacts of non-compliance with these requirements can be observed in the sanitation crisis in Altamira, regarding the provision and quality of services. In summary, it is highlighted that the basic sanitation services mapped in Altamira do not guarantee the protection of the environment and the health of the population. The following year, Gauthier et al. (2019) published a study on an investigation method developed to identify areas susceptible to groundwater and well contamination in relation to existing and proposed hydroelectric projects. Using spatial analytical data and field analysis, the authors identified high-risk locations in the most densely populated neighborhoods of Altamira, the headquarters city of Belo Monte.

Another analysis of large hydroelectric projects was conducted by Mayer et al. (2023), this time investigating their impact on stress levels in the population living near the dams. In addition, the study assessed the impact on hydroelectric power, such as the deterioration of infrastructure (electricity, land, water, and sewage) and the resettlement experience. The results suggest that these projects cause stress in the population through two mechanisms: (i) tensions over community resources (e.g., infrastructure), which reduce well-being; and (ii) the process of population displacement, with the latter being the greatest social impact. Using data from the Madeira River basin in the Brazilian Amazon, the authors found that hydroelectric projects increase stress by reducing access to energy, water, sanitation, and land, and that the compensation provided was not sufficient to moderate this effect.

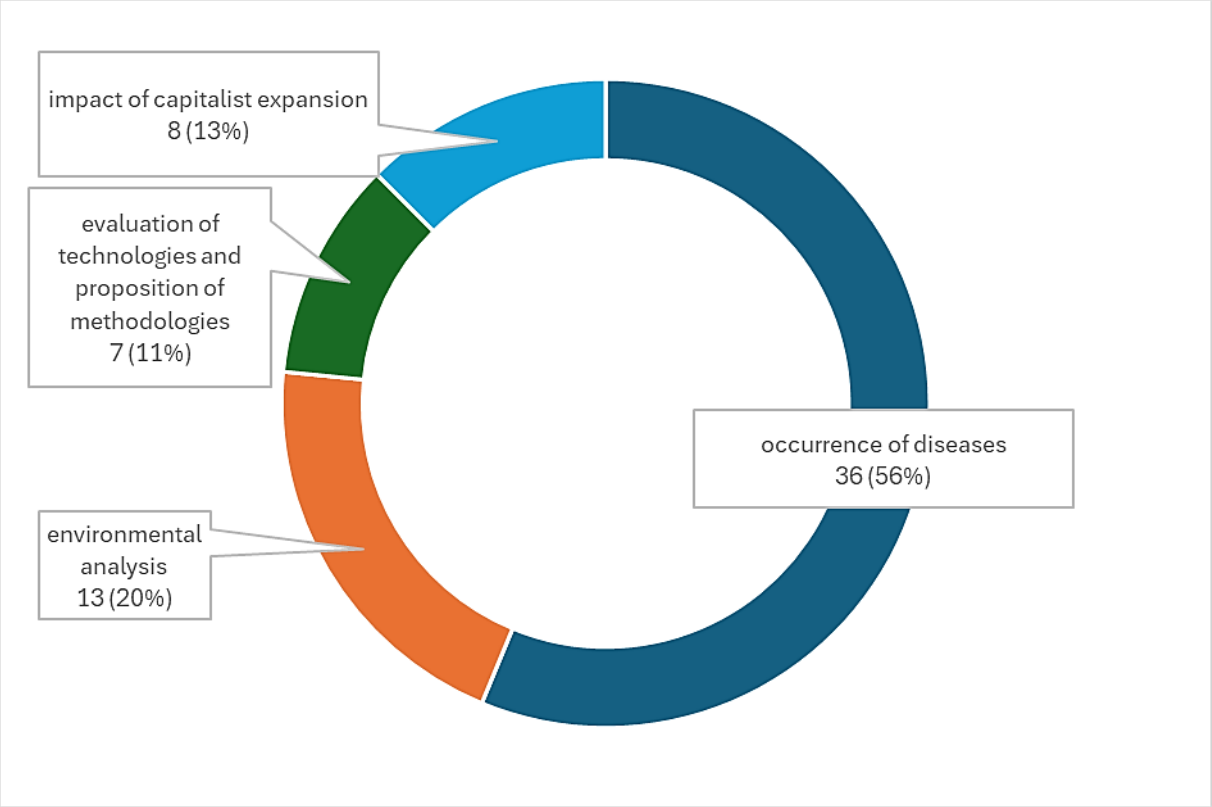
In a more focused analysis on the right to health issues, Gonçalves and Domingos (2019) analyzed public health and basic sanitation policies for the well-being and development of riverside communities in the state of Amazonas. The authors examined issues related to the right to health, public health and sanitation policies, and the precarious access to health care by the riverside population in Amazonas. The mapped panorama includes a lack of basic sanitation, precarious access to health care, transportation, and education, which exacerbates the occurrence of diseases and conditions related to these living conditions. An example of the occurrence of diseases is the spread of arboviruses, such as dengue, chikungunya, and Zika, resulting from the degradation of the tropical forest (due to deforestation, mineral exploitation, and infrastructure projects such as roads and dams), extreme weather events, and climate change (LOWE et al., 2020). In this study, the authors point out that development projects have generated settlements without basic infrastructure in the Brazilian Amazon, with no access to piped water and waste collection. In this context, among the urgent actions to be taken is ensuring universal access to basic sanitation, potable water, and waste management. Castro, Ravena, and Mendes (2019) developed a case study on the governance of stormwater systems in the Amazon. The work identifies the main actors and issues that influence governance for the implementation of stormwater systems, including the concept of security as "the ability to meet the public health (or equivalent) concerns of the existing regime" (p. 65), and the corresponding evidence is the existence of reports of diseases related to the use of rainwater collected from roofs.

The possibility of finding possible paths for reconciling socioeconomic development and nature sustainability motivated the study by Campos-Silva et al. (2021). This is an analysis of the social consequences of living within or outside sustainable use protected areas in the Brazilian Amazon. The authors evaluated different elements of human well-being and their facilitators, within and outside a system of sustainable use protected areas in the Brazilian Amazon, using data from more than 100 local communities along 2,000 km of the Juruá River. The results showed that communities located within Conservation Units have better public services: health, education, electricity, basic sanitation, and communication infrastructure. In addition, living in a Sustainable Use Conservation Unit was the strongest predictor of household wealth, followed by income transfer programs and the number of people per household. This set of collective benefits, in turn, influences life satisfaction, with only 5% of all adult residents in protected areas declaring a desire to move to urban centers, compared to 58% of adults in unprotected areas.

A general landscape of the literature

The four categories of approaches typified here to classify studies on the relationship between sanitation and health in the Legal Amazon, from 2013 to 2023, are shown in Figure 1.

Figure 1. studies about health and sanitation profile according to approaches, 2013 a 2023.



Source: authors.

The most classic approach to understanding the connections between sanitation and health corresponds to establishing a relationship between sanitation conditions and the occurrence of diseases and health issues. More than half of the selected articles (n = 36, approximately 56%) relate to this approach and constitute direct relationships to explain the connection between environmental sanitation and health in the Amazon: the magnitude of diseases and health issues, mainly infectious diseases. Therefore, the studies address a primary but still central issue regarding the fact that inadequate access to basic sanitation increases the population's vulnerability to the transmission of infectious and parasitic diseases.

Overall, these studies have demonstrated a close correlation between precarious sanitation conditions in the Amazon and the occurrence of diseases and health issues. The results clearly show the persistence and relevance of infectious and parasitic diseases, as well as non-communicable chronic diseases and other health issues (such as snakebites), as part of the context of the triple burden of diseases characterizing epidemiological transition in the country (MENDES, 2010). However, it is important to highlight that, although the studies address these three groups, infectious and parasitic diseases constitute the focus, indicating that this

epidemiological profile persists notably in the Amazon due to precarious environmental sanitation conditions.

Regarding the methodologies adopted to analyze the occurrence of diseases and health issues, it was observed that primary sources of information, mainly interviews and health examinations or assessments, were predominantly used. Some authors reported difficulties in obtaining and relying on data from official sanitation and health information systems. This observation aligns with the assessment of the quality of data from the National Sanitation Information System (SNIS) conducted by the Office of the Comptroller General (CGU, 2021). The evaluation identified regional disparities in data quality, with less participation from municipalities in the Northeast and North regions in SNIS data collection.

Analyzing discourses related to the literature in the field of sanitary engineering concerning the sanitation–health–environment relationship, Souza (2007) found a predominantly preventive bias, "(...) which mentions the causal relationship between sanitation and environmental conditions - which can be good or bad, healthy or unhealthy - and the occurrence of diseases." (SOUZA, 2007, p. 133). This causality configuration recalls criticisms of causal explanations in epidemiology that fail to reduce complex phenomena, such as social inequality, into isolated outcomes, such as socioeconomic variables (BARATA, 2023). To overcome these limitations, it is necessary to broaden the theoretical-conceptual approaches to the sanitation and public health relationship, encompassing perspectives of human rights and environmental justice, based on an expanded concept of health and towards health promotion (SILVA et al., 2018).

In this regard, studies on the impact of capitalist expansion are moving forward. By investigating the human and environmental impact of interventions in the region, such as the construction of hydroelectric plants and deforestation, these studies seek to capture the complexity of relationships established within the logic of capitalist accumulation. Beyond socioeconomic variables, inequalities in health and sanitation are analyzed from the perspective of the political nature of these interventions and their consequences, as well as the (limited) possibilities of tension between private and collective interests. Thus, these more recent analyses, of a historical-political nature, although still in smaller numbers than those addressing the occurrence of diseases and health issues, have indicated significant problems and pathways in this area.

CONCLUSION

From the literature review conducted in this article, we found that the predominant approach to sanitation and health in the Legal Amazon from 2013 to 2023 was the one that establishes a connection between sanitation conditions and the occurrence of diseases and ailments, mainly infectious and parasitic diseases. In an analysis of the conceptual frameworks that constitute the relationship between health and sanitation, Heller (1998, p. 74) notes that "the historical trajectory of environmental health has, until this century, been the recognition of the relationship between sanitation and

health." Thus, it was considered necessary to broaden the analysis of this relationship to include contemporary environmental problems and impacts, as well as issues related to the socioeconomic model, including disparities in these issues among different social strata (HELLER, 1998).

On the one hand, there is recognition of the need for theoretical and conceptual expansion and that, in this sense, studies on the relationship between sanitation and health should go beyond the biological view of the health-disease-care process. On the other hand, however, primary issues related to infectious and parasitic diseases have not been exhausted in the Amazon, which has sanitation indicators less favorable than the national average. Therefore, concerning the Legal Amazon, the reflection elaborated by Silva et al. (2018, PAGE??????) on the national agenda regarding health and sanitation in the national context is particularly valid:

> The national framework requires an agenda simultaneously focused on addressing problems related to the lack or deficiency of access to sanitation – such as disease transmission – and on new theoretical-conceptual frameworks, in line with human rights, environmental justice, and health promotion, involving also public policies, education, and social participation.

It can be considered that this theoretical and conceptual expansion is encompassed in studies on the impacts of capitalist expansion in the Legal Amazon, regarding the negative impacts of the installation of hydroelectric complexes and the importance of protected areas for sustainable use for the population's quality of life. Additionally, even the "classic" studies on the occurrence of diseases and ailments presented perspectives that consider the power relations inherent in the dynamics of territories, focusing on indigenous, riverside, and quilombola populations. Studies on the evaluation of sanitation technologies and the proposition of indicators and methods to support studies on sanitation and health in the region were also found. Some of these studies, in fact, were based on the perception of the users themselves regarding the relevance and usefulness of the technologies used. This perspective converges with the idea of strengthening social participation as a guiding principle for the development of sanitation public policies, but also in the academic sphere, as a research agenda (SILVA et al., 2018).

Finally, this review points to the need for advancement in critical reflection on the political, economic, and sociocultural determinants inherent in the connections between sanitation and health in Brazil. According to Heller and Gomes (2014, p. 19), understanding these determinants in the Brazilian context of access to sanitation necessarily requires "an effort to understand the relationships between State, Society, and Capital and their influences on the definition of public policies." However, advancing in this direction requires, in turn, the encouragement and promotion of research and reflections that can encompass these relationships, their results, and impacts on the population. Considering that the Amazon is at the heart of discussions on climate change and, at the same time, faces the persistence of inequalities in access to sanitation, it is considered fundamental that the region be the subject of expanded analyses on these connections.

ACKNOWLEDGMENTS

This research was supported by Amazonas State Research Support Foundation (Fapeam), for granting the funding obtained through Public Notice nº. 007/2021 — Biodiversa/Fapeam, Program: Science, Technology and Innovation for Environment and Biodiversity in the State of Amazonas – year I. We thank Lauro Borges for the valuable support in reviewing the English language of the manuscript.

CONTRIBUIÇÕES DOS AUTORES

Concepção: Regina Lucena e Marcílio Medeiros. Metodologia, análise formal, pesquisa, preparação dos dados e escrita do artigo: Regina Lucena. Revisão: Marcílio Medeiros. Supervisão: Regina Lucena e Marcílio Medeiros. Aquisição de financiamento: Marcilio Medeiros, por meio do Edital N.º 007/2021 — Programa Biodiversa/ Fundação de Amparo à Pesquisa do Amazonas/C,T&I para Ambiência e Biodiversidade no Estado do Amazonas – ano I. Todos os autores leram e concordaram com a versão publicada do manuscrito.

REFERENCES

ALVES FILHO, P.; SANTOS, R. V.; VETTORE, M. V. Social and environmental inequities in dental caries among indigenous population in Brazil: evidence from 2000 to 2007. Revista Brasileira De Epidemiologia, v. 16, n. 3, p. 692–704, 2013. DOI: 10.1590/S1415-790X2013000300013

ANDRADE, L. M. B. et al. Health-related vulnerability to climate extremes in homoclimatic zones of Amazonia and Northeast region of Brazil. PLoS One, v. 16, n. 11, 2021. DOI: 10.1371/journal.pone.0259780

ANJOS, B. K. et al. Intestinal protozoa parasites association with anemia in people from Brazilian western Amazon communities. Health and Diversity, v. 2, n. 1, p. 7–11, 2018. DOI: 10.18227/hd.v2i1.7498

AGUIAR, E. A. et al. Dinâmica espacial e temporal das doenças tropicais negligenciadas no Arquipélago do Marajó, Amazônia-PA. Revista de Epidemiologia e Controle de Infecção, v. 13, n. 2, 2023. DOI: 10.17058/reci.v13i2.17866

ARAÚJO, P. A. et al. Indicadores de abastecimento de água e doenças de transmissão hídrica em municípios da Amazônia Oriental. Engenharia Sanitária e Ambiental, v. 26, n. 6, p. 1059-1068, 2021. DOI: 10.1590/S1413-415220200179

BAIA, C. C. et al. Microbiological Contamination of Urban Groundwater in the Brazilian Western Amazon. Water, v. 14, n. 24, 2022. DOI: 10.3390/w14244023

BALBINO, L. F. et al. Intestinal protozoan infections and environment conditions among rural schoolchildren in Western Brazilian Amazon. Brazilian Journal of Biology, v. 83, n. e247530, p. 1-4. 2023. DOI: 10.1590/1519-6984.247530

BANDEIRA, R. H. L. et al. Fluoride Concentration in Public Water Supply in a City in the Amazon Region. Pesquisa Brasileira em Odontopediatria e Clínica Integrada, v. 22, 2022. DOI: 10.1590/pboci.2022.031

BARCELLOS, C. et al. Health risk assessment associated with the implementation of the madeira ahydroelectric complex, Brazilian Amazon. Ambiente & Sociedade, v. 21, 2018. DOI: 10.1590/1809-4422asoc0019r1vu18L4FT

BERNAL, M. K. M. et al. Marcadores sorológicos para hepatite A entre mamíferos silvestres cativos e de vida livre do Estado do Pará, Brasil. Semina: Ciências Agrárias, v. 42, n. 3, suplemento 1, p. 1635-1646, 2021. DOI: 10.5433/1679-0359.2021v42n3Supl1p1635

BERNARDES, C.; BERNARDES, R. S.; GÜNTHER, W. M. R. Proposta de índice de salubridade ambiental domiciliar para comunidades rurais: aspectos conceituais e metodológicos. Engenharia Sanitaria e Ambiental, v. 23, n. 4, p. 697–706, 2018. DOI: 10.1590/S1413-41522018141631

BORGES-PEDRO, J. P. et al. Assessment of WASH scenarios in urban and rural schools of a small city in the Brazilian Amazon. Acta Amazonica, v. 48, n. 1, p. 75–82. DOI: 10.1590/1809-4392201600263

CALEGAR, D. A. et al. Socioenvironmental Factors Influencing Distribution and Intensity of Soil-Transmitted Helminthiasis in the Brazilian Amazon: Challenges for the 2030 Agenda. Journal of Tropical Medicine, v. 2021, p. 1-9, 2021. DOI: 10.1155/2021/6610181

CAMPOS-SILVA, J. V. et al. Sustainable-use protected areas catalyze enhanced livelihoods in rural Amazonia. Proceedings of the National Academy of Sciences of the United States of America, v. 118, n. 40. DOI: 10.1073/pnas.2105480118. PMID: 34580218; PMCID: PMC8501803.

CASTRO, P. P. C.; RAVENA, N.; MENDES, R. Understanding governance in the implementation of rainwater systems in the Amazon – Belem. Management of Environmental Quality, v. 31, n 1, p. 54-74, 2020. DOI: 10.1108/MEQ-03-2019-0061

CARDOSO, B. A. et al. Environmental aspects related to tuberculosis and intestinal parasites in a low-income community of the Brazilian Amazon. Revista do Instituto de Medicina Tropical de São Paulo, v. 59, n. e57, 2017. DOI: 10.1590/S1678-9946201759057

CGU – Controladoria-Geral da União. Relatório de Avaliação: Secretaria Nacional de Saneamento. Brasília, DF: CGU, 2021. Disponível em <https://eaud.cgu.gov.br/relatorios/download/1088725> Access in 17 mar 2024.

COSTA, J. S. et al. Water, sanitation and covid-19 in the Amazon. Holos, v.5, n. e10803, 2020. DOI: 10.15628/holos.2020.10803

COSTA, N. M. S. V. Amazônia no contexto da acumulação capitalista: a particularidade de pequenas cidades amazônicas. In: VII Jornada Internacional de Políticas Públicas, 2015, São Luís, Maranhão. Anais [...]. Available in <https://www.joinpp.ufma.br/jornadas/joinpp2015/pdfs/eixo11/amazonia-no-contexto-da-acumulacao-capitalista-a-particularidade-de-pequenas-cidades-amazonicas.pdf> Acesso em 18 mar 2024.

COVRE, W. P. et al. Impact of copper mining wastes in the Amazon: Properties and risks to environment and human health. Journal of Hazardous Materials, v. 421, n. 5, 2022. DOI: 10.1016/j.jhazmat.2021.126688

CUNHA, M.P.L.; MARQUES, R.C.; DÓREA, J.G. Child Nutritional Status in the Changing Socioeconomic Region of the Northern Amazon, Brazil. International Journal of Environmental Research and Public Health, v. 15, n. 15, 2018. DOI: 10.3390/ijerph15010015

DELFINO, B. M. et al. Evolution of Socioeconomic Conditions and Its Relation to Spatial–Temporal Changes of Giardiasis and Helminthiasis in Amazonian Children. Ecohealth, v. 13, p. 743-760, 2016. DOI: 10.1007/s10393-016-1167-z

FABREGAT-SAFONT, D. et al. Wide-scope screening of pharmaceuticals, illicit drugs and their metabolites in the Amazon River. Water Research, v. 200, 2021. DOI: 10.1016/j.watres.2021.117251

FERREIRA, D.; SILVA, L.; FIGUEIREDO FILHO, D. B. Saneamento importa? Uma análise da relação entre condições sanitárias e COVID-19 nas capitais brasileiras. Engenharia Sanitaria e Ambiental, v. 26, n. 6, p. 1079–1084, 2021. DOI: 10.1590/S1413-415220200355

FERREIRA, D. C.; LUZ, S. L. B.; BUSS, D. F. Avaliação de cloradores simplificados por difusão para descontaminação de água de poços em assentamento rural na Amazônia, Brasil. Ciência & Saúde Coletiva, v. 21, n. 3, p. 767–76, 2016. DOI: 10.1590/1413-81232015213.23562015

FRAZÃO, P. et al. Cárie dentária em escolares de 12 anos de idade em município sem água fluoretada na Amazônia Ocidental brasileira, 2010. Epidemiologia e Serviços de Saúde, v. 25, n. 1, p. 149–158, 2016. DOI: 10.5123/S1679-49742016000100015

FREITAS, I. G. et al. Perfil sociodemográfico e epidemiológico de uma comunidade quilombola na Amazônia Brasileira. Revista Cuidarte, v. 9, n. 2, p. 2187-200, 2018. DOI: 10.15649/cuidarte.v9i2.521

GAUTHIER, C.; LIN, Z.; PETER, B.; MORAN, E. F. Hydroelectric Infrastructure and Potential Groundwater Contamination in the Brazilian Amazon: Altamira and the Belo Monte Dam. The Professional Geographer, v. 71, n. 2, 2019. DOI: 10.1016/j.geoforum.2018.10.001.

GAUTHIER, C.; MORAN, E. F. Public policy implementation and basic sanitation issues associated with hydroelectric projects in the Brazilian Amazon: Altamira and the Belo Monte dam. Geoforum, v. 97, p. 10-21, 2018. DOI: 10.1016/j.geoforum.2018.10.001.

GIACOMET, C. L. et al. A distributional regression approach to modeling the impact of structural and intermediary social determinants on communities burdened by tuberculosis in Eastern Amazonia – Brazil. Archives of Public Health, v. 81, n. 1, 2023. DOI: 10.1186/s13690-023-01147-7.

GONÇALVES, R. M.; DOMINGOS, I. M. População ribeirinha no Amazonas e a desigualdade no acesso à saúde. Revista de Estudos Constitucionais, Hermenêutica e Teoria do Direito (RECHTD), v. 11, n. 1, p. 99-108, 2019. DOI: 10.4013/rechtd.2019.111.06

GOVEIA, L. A. M. Covid-19 e acesso à água na Amazônia brasileira. Mundo Amazónico, v. 12, n. 1, p. 18-42, 2021. DOI: 10.15446/ma.v12n1.88651

GUERRA, L. D. S. et al. Insegurança alimentar em domicílios com adolescentes da Amazônia Legal Brasileira: prevalência e fatores associados. Cadernos de Saúde Pública, v. 29, n. 2, p. 335–348, 2013. DOI: 10.1590/S0102-311X2013000200020

HELLER, L. Saneamento e Saúde. Brasília: Organização Panamericana de Saúde (Opas), 1998.

HELLER, L.; GOMES, U. A. F. Elementos conceituais para o saneamento básico. Brasília: Ministério das Cidades, 2014.

HERRERA, J. A.; MOREIRA, R. P.; BEZERRA, T. S. L. A Amazônia: expansão do capital e apropriação dos recursos naturais. Revista Brasileira de Gestão e Desenvolvimento Regional, v. 12, n. 2, p. 208-227, 2016.

IBGE – Instituto Brasileiro de Geografia e Estatística. Atlas de saneamento: abastecimento de água e esgotamento sanitário. Rio de Janeiro: IBGE, 2021.

IMADA K. S. et al. Socioeconomic, hygienic, and sanitation factors in reducing diarrhea in the Amazon. Revista de Saúde Pública, v. 50, n. 77, p. 1-10, 2016. DOI: 10.1590/S1518-8787.2016050006505

INFOAMAZONIA. Visaguas: água e doenças na Amazonia Legal. Disponível em <https://visaguas.infoamazonia.org/>. Access in 2 fev 2024.

ISAACSON J. E. et al. (2023) Antivenom access impacts severity of Brazilian snakebite envenoming: a geographic information system analysis. PLOS Neglected Tropical Diseases, v. 17, n. 6, 2023. DOI: 10.1371/journal.pntd.0011305

JESUS, F. O. et al. Eficácia das medidas domiciliares de desinfecção da água para consumo humano: enfoque para o contexto de Santarém, Pará, Brasil. Cadernos de Saúde Pública, v. 39, n. 2, 2023. DOI: 10.1590/0102-311XPT205322

KORTE R. L. et al. Survey of Bancroftian filariasis infection in humans and Culex mosquitoes in the western Brazilian Amazon region: implications for transmission and control. Revista da Sociedade Brasileira de Medicina Tropical, v. 46, n. 2, p. 214–20, 2013. DOI: 10.1590/0037-8682-1708-2013

LOBO, M. A. A. et al. Avaliação econômica de tecnologias sociais aplicadas à promoção de saúde: abastecimento de água por sistema Sodis em comunidades

ribeirinhas da Amazônia. Ciência & Saúde Coletiva, v. 18, n. 7, p. 2119–2127, 2013. DOI: 10.1590/S1413-81232013000700027

LOWE, R. et al. Emerging arboviruses in the urbanized Amazon rainforest. BMJ, v. 371, 2020. DOI: 10.1136/bmj.m4385: 10.1136/bmj.m4385

MANTOVANI, S. A. S. Socioeconomic inequities and hepatitis A virus infection in Western Brazilian Amazonian children: spatial distribution and associated factors. BMC Infectious Diseases, v. 15, n. 428, 2015. DOI: 10.1186/s12879-015-1164-9

MANSUR, A.V. et al. An assessment of urban vulnerability in the Amazon Delta and Estuary: a multi-criterion index of flood exposure, socio-economic conditions and infrastructure. Sustainability Science, v. 11, p. 625–643, 2016. DOI: 10.1007/s11625-016-0355-7

MARINHO G. L. et al. Saneamento básico em domicílios indígenas de áreas urbanas da Amazônia Legal, Brasil. Cadernos de Saúde Coletiva, v. 29, n. especial, p. 177–86, 2021. DOI: 10.1590/1414-462X202199010455

MARQUES, R. C. et al. Intestinal Parasites, Anemia and Nutritional Status in Young Children from Transitioning Western Amazon. International Journal of Environmental Research and Public Health, v. 17, n. 2, 2020. DOI: 10.3390/ijerph17020577

MATOS, G. S. B. et al. Soil potentially toxic element contents in an area under different land uses in the Brazilian Amazon. Heliyon. v. 9, n. 6, 2023. DOI: 10.1016/j.heliyon.2023.e17108

MAYER A. et al. Large hydropower projects increase stress despite compensation efforts: Evidence from the Brazilian Amazon. PLoS ONE, v. 18, n. 7, 2023. DOI: 10.1371/journal.pone.0284760

MENDES, E. V. As redes de atenção à saúde. Ciência & Saúde Coletiva, v. 15, n. 5, p. 2297-2305, 2010. DOI: 2010.v15n5/2297-2305

MESCHEDE, M. S. C. et al. Drinking water quality in schools of the Santarém region, Amazon, Brazil, and health implications for school children. Revista Ambiente & Água, v. 13, n. 6, 2018. DOI: 10.4136/ambi-agua.2218

MONTEIRO, T. H. A. et al. Basic sanitation, socioeconomic conditions, and degree of risk for the presence and maintenance of malaria in a low-transmission area in the Brazilian Amazon. Revista da Sociedade Brasileira de Medicina Tropical, v. 48, n. 5, p. 573–579, 2015. DOI: 10.1590/0037-8682-0118-2015

MOREIRA, V. L. C. et al. Calodium hepaticum (Nematoda: Capillariidae) in synanthropic rodents (Rattus norvegicus and Rattus rattus) in Eastern Amazonia. Revista Brasileira De Parasitologia Veterinária, v. 22, n. 2, p. 265–269.DOI: 10.1590/S1984-29612013000200046

OLIVEIRA, F. B. et al. Spurious infection by Calodium hepaticum (Bancroft, 1983) Moravec, 1982 and intestinal parasites in forest reserve dwellers in Western Brazilian Amazon. Revista do Instituto de Medicina Tropical de São Paulo, v. 64, n. e2, p. 1-7, 2022. DOI: 10.1590/S1678-9946202264002

OLIVEIRA, B.F. et al. Deforestation and climate change are projected to increase heat stress risk in the Brazilian Amazon. Communications Earth & Environment, v. 2, n. 207, 2021. DOI: 10.1038/s43247-021-00275-8

PANTOJA, D. K. S. Q. et al. Cryptosporidium spp. oocysts and Giardia spp. cysts in coatis (Nasua nasua L. 1766) from Pará, Brazil. Acta Veterinaria Brasilica, v. 11, p. 175-179, 2017. DOI: 10.21708/avb.2017.11.3.7128 PAULA, D. L. M. et al. Saneamento nas embarcações fluviais de passageiros na Amazônia: uma análise de risco ao meio ambiente e à saúde por meio da lógica fuzzy. Engenharia Sanitaria e Ambiental, v. 24, n. 2, p. 283–94, 2019. DOI: 10.1590/S1413-41522019150122

PAULA, V. S. et al. High prevalence of hepatitis A in indigenous population in north Brazil. BMC Research Notes, v. 13, n. 458, 2020. DOI: 10.1186/s13104-020-05303-y

PEREIRA, L. C. et al. Effects of the lack of basic public sanitation on the water quality of the Caeté River estuary in northern Brazil. Ecohydrology & Hydrobiology, v. 21, n. 2, p. 299-314, 2021. DOI: 10.1016/j.ecohyd.2020.12.003

PEREIRA, T. M. Hepatitis A seroprevalence in preschool children in Assis Brazil, Acre, Brazil, in 2003 and 2010. International Health, v. 8, n. 2, p. 132–141, 2016. DOI: 10.1093/inthealth/ihv041

QUEIROZ, T. C. L. et al. Human Health Risk Assessment Is Associated with the Consumption of Metal-Contaminated Groundwater around the Marituba Landfill, Amazonia, Brazil. International Journal of Environmental Research and Public Health, v. 19, n. 21, 2022. DOI: 10.3390/ijerph192113865

RIBEIRO, M.R.; DE ABREU, L. C.; LAPORTA, G.Z. Drinking water and rural schools in the Western Amazon: an environmental intervention study. PeerJ Life & Environment, v. 15, n. 6, 2018. DOI: 10.7717/peerj.4993

RIEGER, R. A; PENHA, D. L.; TEIXEIRA, E. A. Waterborne Diseases, Basic Sanitation, and Health: Perspectives for Brazil's Legal Amazon. The Review of Regional Studies, v. 51, n. 1, p. 89-104, 2021.

SALAZAR, G. K. M. et al. Snakebites in "Invisible Populations": A cross-sectional survey in riverine populations in the remote western Brazilian Amazon. PLOS Neglected Tropical Diseases, v. 15, n. 9, 2021. DOI: 10.1371/journal.pntd.0009758

SANTANA, Y. R. T. et al. Tungiasis in the Sanumás Amerindians in the Amazon Rainforest, Brazil: Prevalence, Intensity and Morbidity. Tropical Medicine and Infectious Disease, v. 8, n. 8, 2023a. DOI: 10.3390/tropicalmed8080386

SANTANA, Y. R. T. et al. The Effectiveness of Topical Dimethicone Together with a One Health Approach for the Control of Tungiasis in the Sanumás Communities, Yanomami Territory, Amazon Rainforest: A Real-World Study. Tropical Medicine and Infectious Disease, v. 8, n. 11, 2023b. DOI: 10.3390/tropicalmed8110489

SILVA, L. C. et al. Hospitalisations for mycoses as an indicator of socio-environmental vulnerability in the Brazilian Amazon-Savanna transition region. Mycoses, v. 63, n. 2, 2019. DOI: 10.1111/myc.13036

SILVA, P. N. et al. Saneamento e Saúde: Saneamento: entre os direitos humanos, a justiça ambiental e a promoção da saúde. Rio de Janeiro: Fundação Oswaldo Cruz, 2018. Série Fiocruz. Documentos Institucionais, Coleção Saúde, Ambiente e Sustentabilidade, 6.

SIQUEIRA, J. H. et al. Prevalence of concomitant hypertension and diabetes among adults and elderly living in rural riverside areas in the Amazon. Rural and Remote Health, v. 23, n. 8249, 2023. DOI: 10.22605/RRH8249

SOUSA, R. S. et al. Água e saúde no município de Igarapé-Açu, Pará. Saúde e Sociedade, v.25, n.4, p.1095-1107, 2016. DOI 10.1590/S0104-12902016157497

SOUZA, C. M. N. Relação Saneamento-Saúde-Ambiente: os discursos preventivista e da promoção da saúde. Saúde e Sociedade, v. 16, n. 3, p. 125-137, 2007.

SOUZA C. L.; ANDRADE C. S. Saúde, meio ambiente e território: uma discussão necessária na formação em saúde. Ciência & Saúde Coletiva, v. 19, n. 10, p. 4113–22, 2014. DOI: 10.1590/1413-812320141910.08992014

VASCONCELOS, M. P. A. et al. Malarial and intestinal parasitic co-infections in indigenous populations of the Brazilian Amazon rainforest. Journal of Infection and Public Health, v. 16, n. 4, p. 603-610, 2023. DOI: 10.1016/j.jiph.2023.02.012

VIANA R. L; FREITAS C. M.; GIATTI L. L. Saúde ambiental e desenvolvimento na Amazônia legal: indicadores socioeconômicos, ambientais e sanitários, desafios e perspectivas. Saúde e Sociedade, v. 25, n. 1, p. 233–46, 2016. DOI: 10.1590/S0104-12902016140843

VIEIRA, D. E. A.; BENETTON, M. F. N. Fatores ambientais e socioeconômicos associados à ocorrência de enteroparasitoses em usuários atendidos na rede pública de saúde em Manaus, AM, Brasil. Bioscience Journal, v. 29, n. 2, p. 487-498, 2013.

VITRAL, C. L. et al. Hepatitis A and E seroprevalence and associated risk factors: a community-based cross-sectional survey in rural Amazonia. BMC Infectious Diseases, v. 14, n. 458, 2014. DOI: 10.1186/1471-2334-14-458