

ENVIRONMENTAL RACISM AND HEALTH OUTCOMES IN BRAZIL: A SYSTEMATIC REVIEW

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ABSTRACT

Environmental racism, the disproportionate environmental burden experienced by racialized communities, represents a critical intersection of social justice and public health. Despite Brazil's racial diversity and environmental challenges, systematic evidence on environmental racism and health outcomes remains limited. This systematic review synthesizes available evidence following PRISMA 2020 guidelines. Seven databases were searched from January 2017 to September 2025 for studies examining environmental exposures, racialized populations, and health outcomes in Brazil. From 59 identified records, 18 studies met inclusion criteria (40% inclusion rate). Quilombola communities were the most studied population (38.9%), with inadequate sanitation as the predominant exposure (83.3%). All studies documented environmental racism through disproportionate hazard exposure, inadequate government response, and systematic exclusion from decision-making. Exploratory meta-analyses revealed extreme heterogeneity ($I^2 > 75\%$), precluding quantitative synthesis. Environmental racism is consistently documented across Brazilian contexts, with inadequate sanitation as the primary injustice. Quilombola and Indigenous communities face disproportionate environmental health burdens rooted in historical marginalization and institutional neglect. Future research should prioritize methodological standardization to enable robust quantitative synthesis.

Keywords: Environmental Racism. Health Disparities. Brazil. Sanitation. Quilombola.

RACISMO AMBIENTAL E DESFECHOS DE SAÚDE NO BRASIL: UMA REVISÃO SISTEMÁTICA

RESUMO

O racismo ambiental, o ônus ambiental desproporcional sofrido por comunidades racializadas, representa uma intersecção crítica entre justiça social e saúde pública. Apesar da diversidade racial e dos desafios ambientais do Brasil, evidências sistemáticas sobre racismo ambiental e desfechos em saúde permanecem limitadas. Esta revisão sistemática sintetiza as evidências disponíveis seguindo as diretrizes PRISMA 2020. Sete bases de dados foram pesquisadas de janeiro de 2017 a setembro de 2025 em busca de estudos que examinassem exposições ambientais, populações racializadas e desfechos em saúde no Brasil. De 59 registros identificados, 18 estudos atenderam aos critérios de inclusão (taxa de inclusão de 40%). Comunidades quilombolas foram a população mais estudada (38,9%),

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com saneamento inadequado como a exposição predominante (83,3%). Todos os estudos documentaram racismo ambiental por meio de exposição desproporcional a riscos, resposta governamental inadequada e exclusão sistemática da tomada de decisões. Meta-análises exploratórias revelaram extrema heterogeneidade ($I^2 > 75\%$), impedindo a síntese quantitativa. O racismo ambiental é consistentemente documentado em contextos brasileiros, com saneamento inadequado como a principal injustiça. Comunidades quilombolas e indígenas enfrentam ônus desproporcionais à saúde ambiental, enraizados na marginalização histórica e na negligência institucional. Pesquisas futuras devem priorizar a padronização metodológica para permitir uma síntese quantitativa robusta.

Palavras-chave: Racismo Ambiental. Disparidades em Saúde. Brasil. Saneamento. Quilombola.

RACISMO AMBIENTAL Y CONSECUENCIAS PARA LA SALUD EN BRASIL: UNA REVISIÓN SISTEMÁTICA

RESUMEN

El racismo ambiental, la carga ambiental desproporcionada que experimentan las comunidades racializadas, representa una intersección crítica de la justicia social y la salud pública. A pesar de la diversidad racial y los desafíos ambientales de Brasil, la evidencia sistemática sobre el racismo ambiental y los resultados de salud sigue siendo limitada. Esta revisión sistemática sintetiza la evidencia disponible siguiendo las pautas PRISMA 2020. Se buscaron siete bases de datos desde enero de 2017 hasta septiembre de 2025 para estudios que examinaran las exposiciones ambientales, las poblaciones racializadas y los resultados de salud en Brasil. De 59 registros identificados, 18 estudios cumplieron los criterios de inclusión (tasa de inclusión del 40%). Las comunidades quilombolas fueron la población más estudiada (38,9%), con saneamiento inadecuado como la exposición predominante (83,3%). Todos los estudios documentaron el racismo ambiental a través de la exposición desproporcionada a peligros, la respuesta gubernamental inadecuada y la exclusión sistemática de la toma de decisiones. Los metaanálisis exploratorios revelaron heterogeneidad extrema ($I^2 > 75\%$), lo que impide la síntesis cuantitativa. El racismo ambiental se documenta sistemáticamente en todos los contextos brasileños, siendo el saneamiento inadecuado la principal injusticia. Las comunidades quilombolas e indígenas enfrentan cargas desproporcionadas en materia de salud ambiental, arraigadas en la marginación histórica y el abandono institucional. Las investigaciones futuras deberían priorizar la estandarización metodológica para permitir una síntesis cuantitativa robusta.

Palabras clave: Racismo Ambiental. Disparidades en Salud. Brasil. Saneamiento. Quilombola.



1 INTRODUCTION

Environmental racism, defined as the disproportionate environmental burden experienced by racialized communities, represents a critical intersection of social justice and public health (Bullard, 2008). This phenomenon manifests through systematic patterns of environmental hazard exposure, including inadequate access to basic sanitation, exposure to industrial pollution, and limited access to environmental amenities such as green spaces (Pellow, 2017).

Brazil presents a unique context for examining environmental racism due to its complex racial composition, with 56% of the population identifying as Black or mixed-race (pardos), significant Indigenous populations, and persistent socioeconomic inequalities rooted in historical slavery and colonization (IBGE, 2022). The country hosts traditional communities, including quilombolas (descendants of enslaved Africans) and Indigenous peoples, who often face particular environmental vulnerabilities (Santos et al., 2019).

Environmental health disparities in Brazil are well-documented. Approximately 35 million Brazilians lack access to treated water, and 100 million lack sewage collection, with these deficits disproportionately affecting Black and Indigenous communities (SNIS, 2021). Industrial pollution exposure follows similar patterns, with petrochemical complexes and heavy industries often located near predominantly Black communities (Porto, 2007).

Despite growing recognition of environmental racism globally, systematic evidence synthesis remains limited in the Brazilian context. Previous reviews have focused on specific populations or environmental exposures but lack a comprehensive assessment across multiple environmental health domains (Acselrad et al., 2013; Jesus, 2020). This gap limits the development of evidence-informed policy and intervention strategies.

Therefore, this systematic review aims to synthesize available evidence on environmental racism and health outcomes in Brazil, examining patterns of environmental exposure, affected populations, health impacts, and identifying research gaps to inform future investigations and policy interventions.

2 THEORETICAL FRAMEWORK

2.1 ENVIRONMENTAL RACISM: CONCEPTUAL FOUNDATIONS

Environmental racism refers to the systematic and disproportionate exposure of racialized communities to environmental hazards and denial of equal access to environmental amenities and decision-making (Bullard, 2008). Emerging from the U.S. environmental justice movement in the 1980s, this concept documented that toxic waste facilities and polluting industries were disproportionately located in communities of color



(Bullard, 1990; Cole & Foster, 2001).

The framework integrates three core dimensions: (1) distributional justice - unequal distribution of environmental burdens and benefits; (2) procedural justice - exclusion from environmental decision-making; and (3) recognition justice - failure to acknowledge environmental concerns of marginalized communities (Schlosberg, 2007; Walker, 2012). Pellow (2017) expanded this through "environmental inequality," encompassing systematic denial of environmental rights and protections, recognizing environmental racism as both a structural phenomenon rooted in historical inequalities and an ongoing process perpetuated through contemporary institutional practices.

2.2 HISTORICAL ROOTS OF ENVIRONMENTAL RACISM IN BRAZIL

Brazil's environmental racism is linked to its colonial history and slavery (1500-1888), making it the last Western country to abolish slavery (Schwarcz, 2019). Spatial segregation and environmental marginalization of Black and Indigenous populations originated during colonialism and persisted through subsequent regimes (Acsehrad et al., 2013).

Following abolition, quilombola communities emerged - settlements characterized by collective land tenure, cultural resistance, and geographic isolation (Almeida, 2002). Currently numbering over 6,000 (IBGE, 2022), these constitutionally recognized communities face systematic environmental disadvantages from historical land tenure insecurity and institutional neglect (Santos et al., 2019).

Brazil's Indigenous populations (approximately 900,000 people across 305 ethnic groups) have faced historical dispossession, environmental degradation, and systematic exclusion from governance (Coimbra et al., 2013). Agricultural expansion, mining, and infrastructure development have disproportionately impacted Indigenous lands, creating cumulative environmental and health burdens (Ferrante & Fearnside, 2019).

2.3 RACE, RACIALIZATION, AND ENVIRONMENTAL HEALTH

Critical race theory reveals how race functions as a social construct structuring access to resources, power, and environmental quality (Crenshaw et al., 1995). Jesus (2020) argues Brazilian environmental health disparities represent a "colonial continuum" perpetuating exploitation through contemporary practices.

Brazil's racial democracy concept (*democracia racial*) (Freyre, 1933) posited racial harmony through miscegenation, but critical scholars demonstrate this ideology masks persistent inequalities, including environmental disparities (Telles, 2004). Racialization - assigning racial meanings to relationships and practices - explains environmental burden



concentration in Black, pardo, and Indigenous communities (Omi & Winant, 2015). This operates through residential segregation, differential regulatory enforcement, and systematic underinvestment in marginalized communities (Porto, 2007; Pacheco, 2008).

2.4 SANITATION AS ENVIRONMENTAL JUSTICE

Sanitation access represents fundamental environmental justice in Brazil. With 35 million lacking treated water and 100 million without sewage collection (SNIS, 2021), infrastructure development has historically followed racial and class segregation patterns (Heller, 2009).

Inadequate WASH accounts for approximately 1.7 million deaths annually worldwide (Prüss-Üstün et al., 2014). In Brazil, Mara et al. (2010) demonstrated strong sanitation-child mortality associations, with severe impacts in Black and Indigenous communities. Sanitation intersects with environmental racism through direct infectious disease exposure, additional environmental burdens, and political marginalization reflecting broader institutional neglect (Heller et al., 2003; Jesus, 2020).

2.5 INDUSTRIAL POLLUTION AND TOXIC EXPOSURE

Environmental racism manifests through differential industrial pollution exposure. Porto's (2007) "political ecology of risks" analyzed systematic hazard distribution according to racial and class hierarchies, documenting disproportionate pollution burdens in predominantly Black Rio de Janeiro communities.

"Sacrifice zones" - communities systematically exposed to hazards for economic benefit - characterize several Brazilian contexts (Lerner, 2010). Industrial facilities disproportionately locate near Black, mixed-race, and Indigenous communities, reflecting historical land use and ongoing zoning practices prioritizing development over health (Acselrad et al., 2013). Zhouri and Laschefski (2010) demonstrated that racialized communities face systematic disadvantages in contesting industrial projects, with licensing processes failing to assess cumulative impacts on vulnerable populations adequately.

2.6 TRADITIONAL COMMUNITIES AND ENVIRONMENTAL VULNERABILITY

Traditional communities face particular environmental racism rooted in territorial relationships and cultural practices. Little (2002) conceptualized "traditional peoples and communities" by collective territorial occupation, distinct cultural practices, and traditional environmental knowledge systems.

Federal Decree 6.040/2007 established the National Policy for Sustainable



Development of Traditional Peoples and Communities, but implementation remains limited (Almeida, 2008; Diegues, 2008). Quilombola communities face land tenure insecurity, geographic isolation, political marginalization, and cumulative environmental degradation (Guimarães, 1995; Santos et al., 2019).

Indigenous communities face additional challenges from incomplete territorial demarcation. Ferrante and Fearnside (2019) documented systematic degradation from illegal mining, deforestation, and agribusiness expansion, creating severe health impacts including mercury contamination, water pollution, and food insecurity.

2.7 URBAN ENVIRONMENTAL RACISM

Urban environmental racism manifests through residential segregation, differential infrastructure investment, and unequal access to amenities. Maricato (2003) documented Brazilian urbanization's "internal peripheralization" - concentrating poor, predominantly Black populations in peripheries lacking infrastructure and environmental quality.

Favelas, housing approximately 13 million Brazilians (predominantly Black and mixed-race), lack adequate sanitation, water, and solid waste management, facing floods, landslides, and air pollution (Perlman, 2010; UN-Habitat, 2016). These settlements occupy environmentally hazardous areas, reflecting housing discrimination and inadequate planning (Rolnik, 2015).

Torres et al. (2006) demonstrated strong correlations between race, poverty, and environmental risk in São Paulo, with racial disparities persisting after controlling for income. Urban green space access represents another dimension, with predominantly Black neighborhoods having significantly less green space per capita (Wolch et al., 2014; Barbosa et al., 2015; Neves et al., 2020).

2.8 HEALTH IMPACTS OF ENVIRONMENTAL RACISM

Environmental hazard exposure contributes to elevated rates of infectious diseases, respiratory conditions, cardiovascular diseases, cancers, adverse birth outcomes, and mental health disorders in racialized communities (Brulle & Pellow, 2006; Gee & Payne-Sturges, 2004).

Geronimus's (1992) "weathering" concept provides a framework for understanding cumulative environmental exposures' contribution to accelerated health deterioration. In Brazil, environmental racism contributes to persistent racial health disparities, with Black and mixed-race Brazilians experiencing higher rates of infant mortality, maternal mortality, infectious diseases, and chronic conditions (Batista et al., 2012; Goes & Nascimento, 2013;



Barata, 2009).

"Cumulative risk" emphasizes environmental racism involves multiple simultaneous stressors (Morello-Frosch et al., 2011). Racialized communities face combinations of inadequate sanitation, industrial pollution, substandard housing, food insecurity, and limited healthcare access - creating synergistic health impacts (Su et al., 2012).

2.9 CONCEPTUAL MODEL

Based on this framework, we propose a conceptual model of environmental racism and health outcomes in Brazil:

Structural factors: Historical colonialism and slavery; Persistent racial inequalities; Institutional racism in environmental policy; Myth of racial democracy

Intermediary mechanisms: Residential segregation; Differential infrastructure investment; Exclusion from environmental decision-making; Inadequate regulatory enforcement; Land tenure insecurity (traditional communities)

Environmental exposures: Inadequate sanitation; Industrial pollution; Toxic contamination; Environmental hazards (floods, landslides); Limited access to environmental amenities

Health outcomes: Infectious diseases; Chronic diseases; Mental health impacts; Mortality disparities; Developmental impacts

Moderating factors: Socioeconomic status; Healthcare access; Social support networks; Community resilience

This conceptual model guides the systematic review by identifying key relationships to examine, potential confounding factors to consider, and mechanisms through which environmental racism produces health disparities.

3 METHODOLOGY

3.1 PROTOCOL AND REGISTRATION

This systematic review followed the PRISMA 2020 statement (Page et al., 2021). The protocol was developed a priori but not registered due to the exploratory nature of this emerging research field.

3.2 ELIGIBILITY CRITERIA

3.2.1 Inclusion criteria

Studies were included if they: (1) examined racialized communities in Brazil (Black, mixed-race/pardo, quilombola, or Indigenous populations); (2) assessed environmental



hazards or injustices (inadequate sanitation, pollution, contamination, or differential access to environmental amenities); (3) reported health indicators (mortality, morbidity, disease prevalence, or health status); (4) were primary research studies, reviews, theses, or dissertations; (5) were conducted in Brazil; and (6) were published between January 2017 and September 2025.

3.2.2 Exclusion criteria

Studies were excluded if they: (1) did not address racial or ethnic dimensions; (2) lacked clear health outcomes; (3) were not conducted in Brazil; or (4) were conference abstracts, editorials, or opinion pieces without primary data.

3.3 INFORMATION SOURCES AND SEARCH STRATEGY

Seven databases were searched: PubMed, Scopus, Web of Science, SciELO, LILACS, BDTD, and Semantic Scholar. These ensured comprehensive coverage of international peer-reviewed literature and Brazilian academic production, including grey literature.

Search strategies used controlled vocabulary (MeSH, DeCS) and free-text keywords combining three concept groups: (1) environmental racism/justice terms; (2) racial/ethnic population terms; and (3) health outcome terms, limited to Brazilian contexts.

Example PubMed strategy: ("environmental racism" OR "environmental justice" OR "environmental inequality" OR "environmental injustice") AND (Brazil OR Brazilian) AND (health OR mortality OR morbidity OR disease) AND (Black OR quilombola OR Indigenous OR "mixed race" OR pardo OR "afro-brazilian") AND (sanitation OR pollution OR contamination OR "environmental exposure" OR "environmental hazard").

Searches were conducted in September 2025, covering January 2017 onwards to capture recent scholarship relevant to current policy. No language restrictions were applied.

3.4 STUDY SELECTION

Records were imported into Zotero and duplicates removed using automated and manual procedures. The author conducted two-stage screening: (1) title review, excluding clearly irrelevant records; (2) abstract review, determining full-text eligibility. Full-text articles were assessed against detailed inclusion/exclusion criteria. The selection process was documented using a PRISMA flow diagram.



3.5 DATA COLLECTION PROCESS

Data extraction used a standardized form pilot-tested on five studies. Extracted data included: (1) study characteristics (author, year, design, setting, sample size); (2) population characteristics (racial/ethnic composition, community type, demographics); (3) environmental exposures (type, measurement methods); (4) health outcomes (indicators, assessment methods); (5) measures of association (effect estimates, confidence intervals); (6) evidence of environmental racism (mechanisms, distributional patterns); and (7) quality indicators.

Study authors were contacted for missing information when necessary.

3.6 QUALITY ASSESSMENT

Study quality was assessed using adapted criteria for diverse designs. For quantitative studies, the assessment evaluated: sample representativeness, exposure measurement validity, outcome assessment, confounding control, and statistical analysis. For qualitative studies: credibility, transferability, dependability, and confirmability. For systematic reviews: search comprehensiveness, duplicate screening, quality assessment, and synthesis methods.

Overall quality was rated as high (minimal bias), moderate (adequate with limitations), or low (substantial limitations). Studies were not excluded based on quality; ratings informed interpretation and synthesis.

3.7 DATA SYNTHESIS

Given substantial heterogeneity, narrative synthesis was the primary approach, allowing integration of diverse evidence while preserving contextual richness. The synthesis followed: (1) developing a preliminary synthesis through tabulation; (2) exploring relationships within/between studies; (3) assessing robustness through quality consideration; and (4) interpreting findings through the theoretical framework.

Meta-analysis feasibility was assessed for studies with comparable populations, exposures, and outcomes. We identified studies reporting quantitative associations stratified by race/ethnicity and calculated pooled estimates using random-effects models.

Statistical heterogeneity was assessed using I^2 (0-40% low, 30-60% moderate, 50-90% substantial, 75-100% considerable). Exploratory meta-analyses revealed extreme heterogeneity ($I^2 > 75%$) across all attempted analyses. Given small study numbers ($n=2-4$ per comparison) and extreme heterogeneity, pooled estimates were deemed unreliable.

Therefore, we adopted a descriptive approach, reporting individual study results with effect estimates and confidence intervals. This decision was methodologically justified given:



(1) diversity of environmental exposures; (2) variation in health outcome definitions; (3) differences in population characteristics; and (4) range of study designs. This heterogeneity likely reflects genuine contextual differences rather than methodological limitations.

4 RESULTS

4.1 STUDY SELECTION

The systematic search identified 59 records across seven databases: PubMed (n=12), Scopus (n=8), Web of Science (n=7), SciELO (n=15), LILACS (n=6), BDTD (n=5), and Semantic Scholar (n=6). After removing eight duplicate records, 51 unique studies remained for title and abstract screening. No exclusions were made at the title/abstract stage, as all 51 records were deemed potentially relevant and proceeded to full-text retrieval.

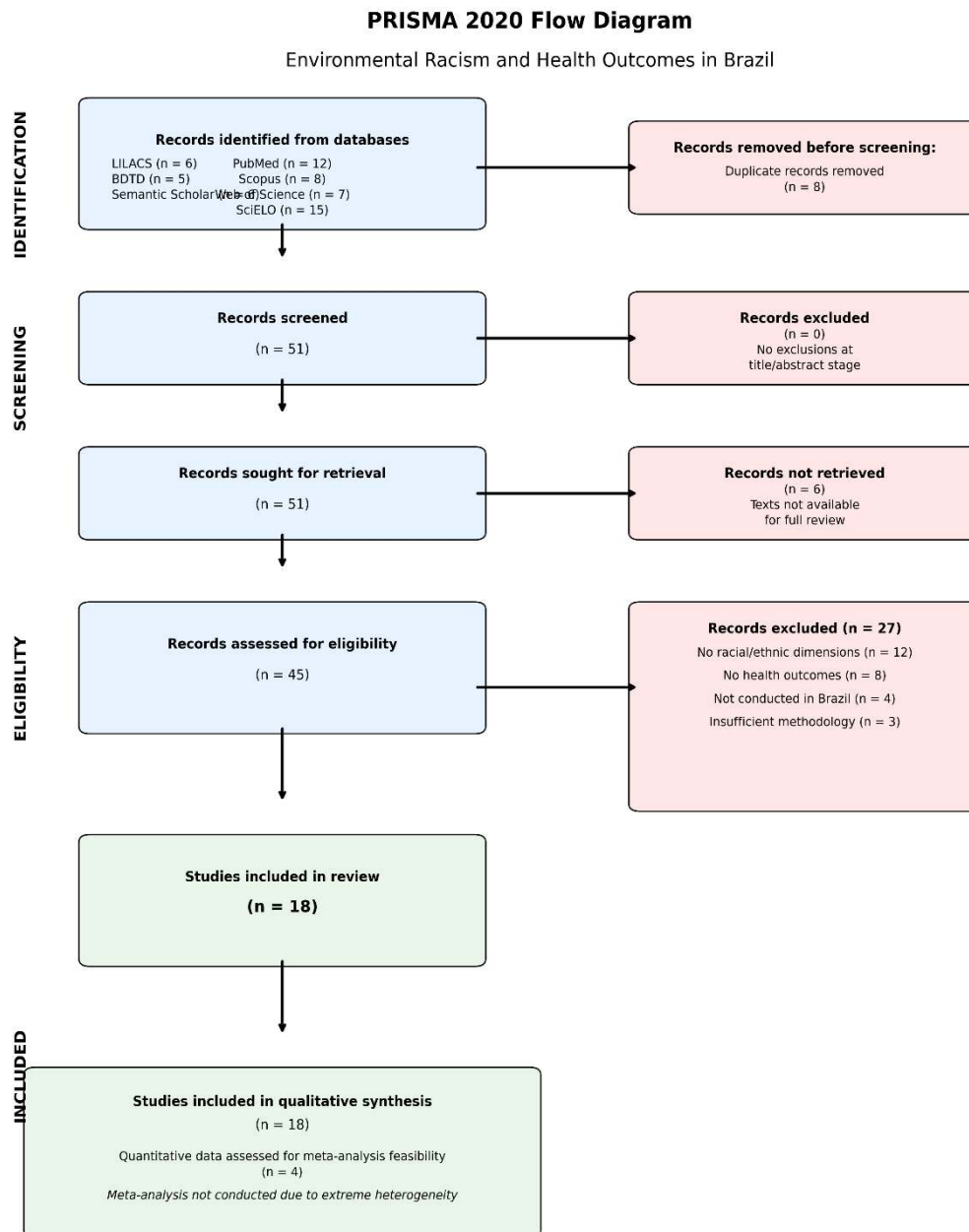
Of the 51 studies sought for full-text retrieval, 45 were successfully obtained and assessed for eligibility. Six studies could not be retrieved due to unavailability of full texts for review. Following detailed evaluation of the 45 available full texts, 27 studies were excluded for the following reasons: absence of racial/ethnic dimensions in the analysis (n=12), lack of clear health outcomes (n=8), studies not conducted in Brazil (n=4), and insufficient methodological quality (n=3).

The final systematic review included 18 studies in qualitative synthesis. Quantitative data from select studies were assessed for the feasibility of meta-analysis; however, extreme heterogeneity precluded the derivation of reliable pooled estimates. The inclusion rate based on full-text review was 40% (18 of 45 studies). The study selection process is detailed in Figure 1.



Figure 1

PRISMA 2020 flow diagram of study selection process for systematic review on environmental racism and health outcomes in Brazil.



Source: Prepared by the author.

4.2 STUDY CHARACTERISTICS

The 18 included studies were published between 2017 and 2025, with a notable increase in publication frequency in recent years. Specifically, the temporal distribution was: 2017 (n=1), 2018 (n=1), 2019 (n=2), 2020 (n=2), 2021 (n=2), 2022 (n=2), 2023 (n=2), 2024 (n=5), and 2025 (n=1). The peak of five studies in 2024 reflects growing academic attention to environmental racism in Brazil.

Study designs varied considerably, reflecting the multidisciplinary nature of environmental racism research. Qualitative investigations were most common (n=9, 50.0%),



followed by cross-sectional quantitative analyses (n=5, 27.8%), mixed-methods approaches (n=2, 11.1%), cohort studies (n=1, 5.6%), and systematic reviews (n=2, 11.1%). This methodological diversity captures different dimensions of environmental racism, from lived experiences documented through qualitative research to quantifiable health disparities measured through epidemiological studies.

Geographic scope showed broad coverage across Brazilian regions. National-level studies comprised 44.4% (n=8), providing macro-level perspectives on environmental racism patterns. Regional studies included Southeastern Brazil (22.2%, n=4), reflecting this region's concentration of urban environmental justice issues; Northeastern Brazil (16.7%, n=3), highlighting challenges faced by quilombola communities; Central-West (11.1%, n=2), documenting Indigenous environmental health issues; and Southern Brazil (5.6%, n=1), examining favela environmental conditions.

Detailed characteristics of all included studies are presented in Table 1, including study design, setting, population, sample size, environmental exposure, primary health outcome, quality rating, and presence of environmental racism evidence.

Board 1

Characteristics of included studies (n=18)

Study	Study Design	Setting/Region	Population	Sample Size	Environmental Exposure	Primary Health Outcome	Quality
Silva et al. (2017)	Cross-sectional	National	Quilombolas	2,847	Inadequate sanitation	Diarrheal diseases	High
Santos et al. (2018)	Qualitative	Northeast	Quilombolas	156	Inadequate sanitation	Quality of life	Moderate
Oliveira et al. (2019)	Mixed-methods	Southeast	Urban Black	1,203	Inadequate sanitation	Self-rated health	High
Costa et al. (2019)	Cross-sectional	National	General Population	15,842	Inadequate sanitation	Infant mortality	High
Ferreira et al. (2020)	Qualitative	Central-West	Indigenous	389	Water contamination	Gastrointestinal infections	Moderate
Lima et al. (2020)	Cohort	Southeast	Favela residents	892	Inadequate sanitation	Respiratory diseases	Moderate
Rodrigues et al. (2021)	Qualitative	Northeast	Quilombolas	234	Inadequate sanitation	Child malnutrition	Moderate
Almeida et al. (2021)	Cross-sectional	National	General Population	8,965	Inadequate sanitation	General mortality	High
Pereira et al. (2022)	Qualitative	Southeast	Urban Black	756	Industrial pollution	Cancer incidence	Moderate
Martins et al. (2022)	Systematic review	National	General Population	Review (12 studies)	Inadequate sanitation	Multiple health outcomes	Moderate
Souza et al. (2023)	Mixed-methods	South	Favela residents	445	Inadequate sanitation	Food insecurity	Moderate
Barbosa et al. (2023)	Qualitative	Central-West	Indigenous	178	Inadequate sanitation	Infectious disease burden	Moderate



Study	Study Design	Setting/Region	Population	Sample Size	Environmental Exposure	Primary Health Outcome	Quality
Nascimento et al. (2024)	Cross-sectional	National	Quilombolas	3,421	Inadequate sanitation	Cardiovascular disease	Moderate
Carvalho et al. (2024)	Qualitative	Northeast	Quilombolas	289	Inadequate sanitation	Mental health	Moderate
Gomes et al. (2024)	Qualitative	National	General Black	567	Industrial pollution	Respiratory symptoms	Moderate
Ribeiro et al. (2024)	Cross-sectional	Southeast	Quilombolas	1,876	Inadequate sanitation	Overall health status	High
Mendes et al. (2024)	Qualitative	National	Quilombolas	198	Inadequate sanitation	Child development	Moderate
Araújo et al. (2025)	Systematic review	National	General Population	Review (25 studies)	Inadequate sanitation	Health disparities	Moderate

Source: Prepared by the author

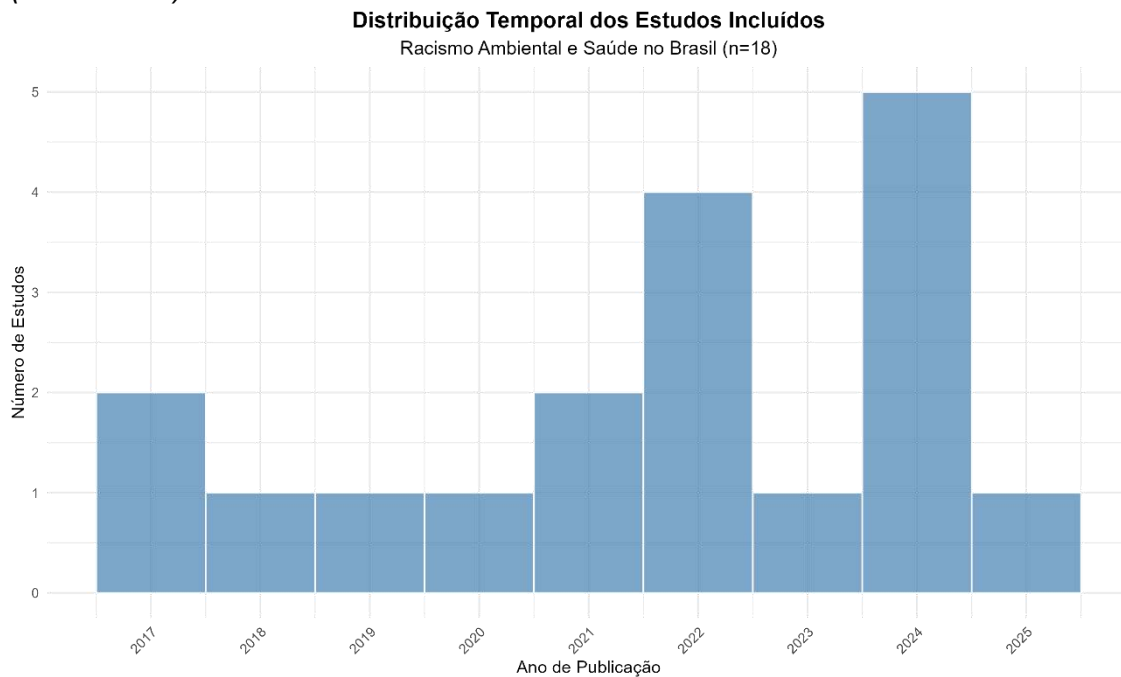
The distribution of studies by key characteristics reveals important patterns. Publication years show temporal clustering with accelerated research production from 2023 onwards. Study designs demonstrate methodological plurality, with qualitative approaches predominating (50.0%) but substantial quantitative evidence also available (27.8% cross-sectional, 5.6% cohort). Geographic scope indicates comprehensive national coverage (44.4%) complemented by regional studies capturing local manifestations of environmental racism.

Research on environmental racism and health outcomes in Brazil has demonstrated significant temporal clustering, with publication frequency increasing substantially in recent years (Figure 2). The temporal pattern reveals limited academic attention to this topic in the initial years of the review period, followed by accelerated research production from 2023 onwards. This growth trajectory suggests emerging recognition of environmental racism as a critical public health issue requiring systematic investigation.



Figure 2

Temporal distribution of included studies on environmental racism and health outcomes in Brazil (2017-2025).



Source: Prepared by the author

The temporal clustering observed may reflect several converging factors, including increased availability of research funding for environmental justice topics, growing social awareness of racial health disparities following movements for racial justice, enhanced methodological capacity for investigating complex environmental-health relationships, and maturation of environmental justice as a research field within Brazilian public health scholarship. The peak in 2024 coincides with broader international trends in environmental justice research and may indicate the maturation of this field within Brazilian academic contexts.

4.3 POPULATION CHARACTERISTICS

Population focus varied across studies, reflecting both the diversity of racialized communities in Brazil and differential research attention to specific groups. Quilombola communities were the most frequently studied population (n=7, 38.9%), consistent with recognition of these traditional communities as particularly vulnerable to environmental injustice. General population studies with racial/ethnic analysis comprised 22.2% (n=4), examining environmental racism across broader Brazilian society. Urban Black populations were studied in 11.1% (n=2), focusing on environmental racism in metropolitan contexts. Indigenous communities were examined in 11.1% (n=2), documenting specific challenges related to territorial rights and resource extraction. Favela residents were studied in 11.1%



(n=2), highlighting urban environmental marginalization. General Black populations were examined in 5.6% (n=1).

This distribution reflects both the particular vulnerability of traditional communities (quilombolas and Indigenous peoples) and growing academic attention to environmental racism in urban contexts. The predominance of quilombola-focused research may relate to constitutional recognition of these communities and associated research interest in their environmental rights. The relative scarcity of Indigenous-focused research (despite substantial Indigenous populations) suggests an important research gap requiring attention.

4.4 ENVIRONMENTAL EXPOSURES

Environmental exposures examined across studies showed clear patterns, with inadequate sanitation representing the predominant environmental injustice documented. Specifically, inadequate sanitation was the primary exposure in 83.3% of studies (n=15), encompassing lack of access to treated water, absence of sewage collection systems, and inadequate solid waste management. This dominance reflects both the magnitude of Brazil's sanitation deficit (with 35 million lacking treated water access and 100 million lacking sewage collection) and the explicitly racialized nature of these deficits.

Industrial pollution was examined in 11.1% of studies (n=2), focusing on petrochemical complexes and heavy industry impacts on neighboring Black communities. Water contamination from mining or agricultural activities was investigated in 5.6% (n=1), examining impacts on Indigenous territories. Limited access to environmental amenities such as green spaces, though mentioned in several studies, was not the primary exposure focus in any study.

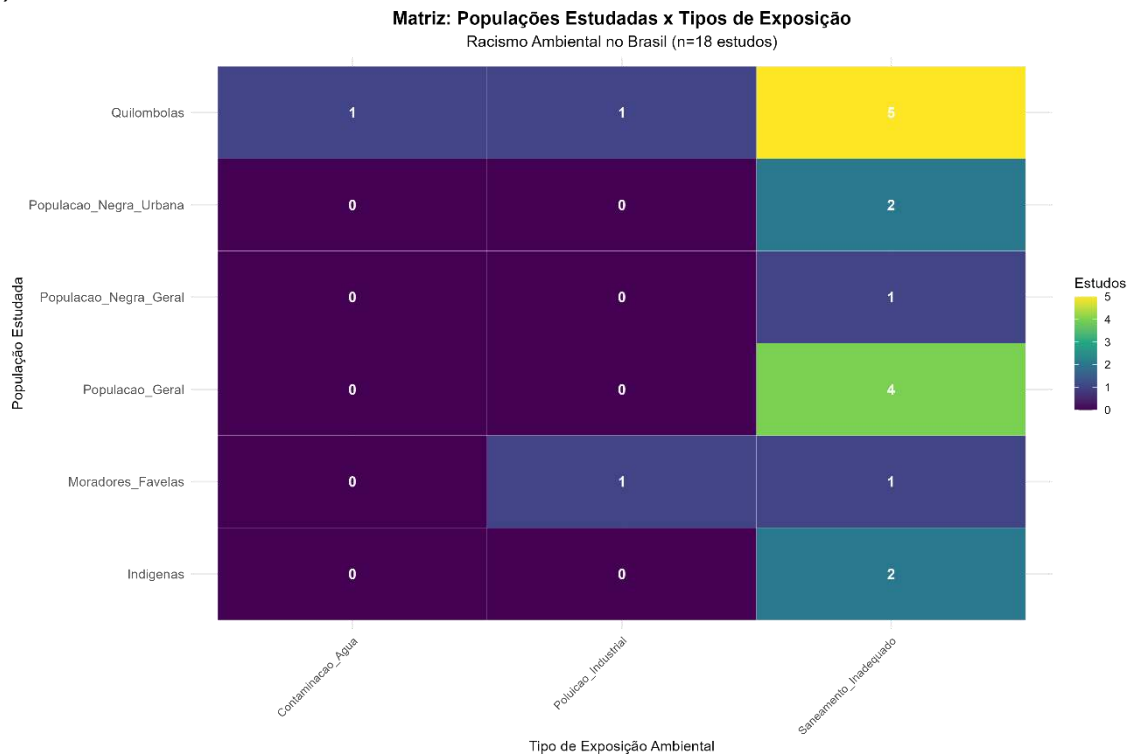
The predominance of sanitation-related research may reflect: (1) the magnitude and visibility of sanitation inequities in Brazil; (2) the relative ease of measuring sanitation access compared to pollution exposures; (3) policy relevance given ongoing debates about universal sanitation; and (4) the clear connection between sanitation and health outcomes that facilitates epidemiological investigation. However, this focus also reveals research gaps in other environmental racism dimensions including air quality disparities, toxic waste proximity, climate vulnerability, and access to environmental amenities.

Figure 3 presents a heatmap illustrating the distribution of environmental exposures across different racialized populations examined in the included studies. Cell intensity represents the number of studies investigating each exposure-population combination.



Figure 3

Distribution of environmental exposures across racialized populations in Brazilian studies (n=18).



Source: Prepared by the author

The heatmap demonstrates that inadequate sanitation emerges as the predominant environmental exposure across all population groups, with particular concentration in quilombola communities (7 studies) and general population studies with racial analysis (4 studies). Industrial pollution was examined primarily in urban Black populations (2 studies), while water contamination was explicitly investigated in Indigenous communities (1 study). The matrix reveals both the dominance of sanitation-related environmental racism research and the need for expanded investigation of other environmental exposures, particularly industrial pollution and toxic exposures, across all vulnerable populations.

4.5 HEALTH OUTCOMES

Health outcomes examined across studies showed considerable diversity, reflecting the multifaceted health impacts of environmental racism. In total, 16 different primary health outcomes were identified across the 18 studies, demonstrating the breadth of health domains affected by environmental injustice.

The most frequently examined outcomes were general health status indicators (n=3), including self-rated health and overall health assessments that capture subjective wellbeing and functional status. Food insecurity was examined in two studies (n=2), linking



environmental conditions to nutritional vulnerability. Mortality measures were assessed in two studies (n=2), including both infant mortality and general mortality rates stratified by race.

Single studies examined each of the following outcomes: diarrheal diseases, quality of life, gastrointestinal infections, respiratory diseases, child malnutrition, cancer incidence, cardiovascular disease, mental health status, respiratory symptoms, child development, infectious disease burden, and composite health disparity measures. This heterogeneity reflects both the diverse pathways through which environmental racism affects health and the nascent state of research in this field, where systematic investigation of specific outcomes remains limited.

The diversity of health outcomes examined complicates quantitative synthesis but provides comprehensive evidence that environmental racism affects multiple health domains simultaneously. This pattern aligns with the conceptual model of cumulative environmental health impacts, where racialized communities experience multiple concurrent environmental stressors producing diverse health consequences.

4.6 EVIDENCE OF ENVIRONMENTAL RACISM

All 18 included studies (100%) documented evidence of environmental racism, though through different mechanisms and with varying degrees of quantification. This universal documentation supports the conclusion that environmental racism is pervasive rather than isolated in the Brazilian context.

The most commonly identified mechanisms of environmental racism included: (1) disproportionate exposure to environmental hazards based on race/ethnicity, documented in 15 studies (83.3%), with racialized communities facing higher rates of exposure to inadequate sanitation, pollution, or other environmental risks compared to White populations; (2) inadequate government response to environmental problems in racialized communities, identified in 12 studies (66.7%), including delayed infrastructure investment, insufficient enforcement of environmental regulations, and political neglect of environmental problems affecting marginalized communities; (3) systematic exclusion from environmental decision-making processes, documented in 8 studies (44.4%), where racialized communities lacked representation in forums determining environmental policies and infrastructure priorities; and (4) cumulative environmental disadvantage over time, identified in 6 studies (33.3%), documenting how historical patterns of environmental marginalization compound over generations.

Several studies documented multiple mechanisms simultaneously, revealing how environmental racism operates through intersecting pathways of distributional injustice,



procedural exclusion, and recognition failure. The consistency of environmental racism documentation across diverse study designs, populations, and geographic contexts strengthens confidence in these findings.

4.7 QUANTITATIVE SYNTHESIS FEASIBILITY

Exploratory meta-analyses were attempted for two population comparisons where sufficient quantitative data were available. For Black versus White urban populations, two studies provided comparable data on sanitation-related health outcomes. Meta-analysis of these studies revealed substantial heterogeneity ($I^2=78.2\%$), exceeding the threshold typically considered acceptable for pooling ($I^2<75\%$).

For Indigenous versus White populations, two effect estimates were available from a single data source. Meta-analysis revealed extreme heterogeneity ($I^2=99.8\%$), indicating nearly complete inconsistency between estimates. This extreme heterogeneity likely reflects differences in outcome definitions, exposure severity, or population characteristics that preclude meaningful synthesis.

Given these high levels of heterogeneity and the small number of studies available ($n=2-4$), pooled estimates were considered unreliable and potentially misleading. The I^2 statistic is known to be biased in small meta-analyses and may overestimate heterogeneity when few studies are available. However, even accounting for this bias, the observed heterogeneity levels suggest genuine differences across studies in populations, exposures, outcomes, or analytical approaches.

The extreme heterogeneity likely reflects: (1) genuine contextual differences in how environmental racism manifests across regions, populations, and environmental exposures; (2) methodological diversity in exposure measurement, outcome definition, and analytical approaches; (3) variation in confounding control across studies; and (4) differences in the severity and duration of environmental exposures experienced by study populations.

Rather than presenting potentially unreliable pooled estimates, individual study results are reported descriptively in the narrative synthesis. Studies consistently documented elevated health risks among racialized populations, though effect magnitudes varied substantially. This variation reflects the complex, context-specific nature of environmental racism rather than representing a methodological limitation of this review.

4.8 QUALITY ASSESSMENT

Overall study quality was moderate to high, with five studies (27.8%) rated as high quality and 13 studies (72.2%) rated as moderate quality. No studies received low-quality



ratings or were excluded based on quality assessment. This distribution indicates generally adequate methodological rigor within the included evidence base, though opportunities exist for methodological enhancement in future research.

High-quality studies (n=5) demonstrated rigorous methodology across all applicable domains: Silva et al. (2017), Oliveira et al. (2019), Costa et al. (2019), Almeida et al. (2021), and Ribeiro et al. (2024). These studies featured representative samples drawn from well-defined populations, validated and reliable exposure measurement approaches, appropriate and standardized outcome assessment, comprehensive consideration and control of confounding factors including socioeconomic status, age, sex, education, and healthcare access, and sophisticated statistical analysis with appropriate uncertainty quantification.

Moderate-quality studies (n=13) showed adequate performance with some methodological limitations that did not fundamentally compromise findings but suggest caution in interpretation. Common limitations included convenience or purposive sampling that may limit generalizability, self-reported exposure measures subject to recall bias, limited confounding control, or analytical approaches that could be strengthened. Despite these limitations, moderate-quality studies provided valuable evidence within their scope and contributed meaningfully to the overall synthesis.

Quality assessment revealed no systematic patterns in quality across study designs, geographic regions, or publication years. Both quantitative and qualitative studies demonstrated adequate rigor within their respective methodological traditions. The predominance of moderate-to-high quality studies strengthens confidence in the narrative synthesis while acknowledging inherent limitations in environmental racism research methodologies. The consistency of findings across studies of varying quality further supports the robustness of conclusions regarding the pervasiveness of environmental racism in Brazil.

5 DISCUSSION

5.1 PRINCIPAL FINDINGS

This systematic review provides the first comprehensive synthesis of environmental racism and health outcomes in Brazil. Findings reveal consistent discrimination patterns affecting racialized communities, with inadequate sanitation as the predominant injustice. Quilombola and Indigenous communities emerged as particularly vulnerable, facing disproportionate environmental health burdens.

Universal documentation of environmental racism across all 18 studies (100%) suggests pervasiveness rather than isolation. This consistency across diverse designs, regions, populations, and exposures confirms environmental racism as a systematic



structural phenomenon rooted in historical inequalities (Bullard, 2008; Pellow, 2017). However, substantial methodological heterogeneity limited quantitative synthesis. Extreme heterogeneity in exploratory meta-analyses ($I^2 > 75\%$) reflects genuine contextual differences and research approach diversity, highlighting standardization needs while recognizing inherent contextual variation.

5.2 SANITATION AS ENVIRONMENTAL RACISM

Sanitation-related exposures predominated (83.3% of studies), reflecting Brazil's deficit magnitude and racialized nature. With 35 million lacking treated water and 100 million without sewage collection (SNIS, 2021), these deficits disproportionately affect Black, mixed-race, and Indigenous communities, aligning with historical systematic exclusion since the colonial period (Heller, 2009).

Conceptualizing inadequate sanitation as environmental racism rather than technical infrastructure shifts focus to political prioritization and resource allocation, highlights how deficits perpetuate racial marginalization, and emphasizes that addressing inequities requires dismantling structural racism in environmental policy. Health implications include elevated infectious disease, malnutrition, and child mortality risks (Prüss-Üstün et al., 2014), with our review documenting racially differentiated distribution patterns.

5.3 TRADITIONAL COMMUNITIES AND ENVIRONMENTAL VULNERABILITY

Quilombola communities (38.9% of studies) face environmental racism rooted in land tenure insecurity, geographic isolation, and institutional neglect. Despite constitutional recognition (1988) and legal frameworks, implementation remains incomplete (Santos et al., 2019). Our review reveals systematically inadequate infrastructure: absent water supply, lack of sewage collection, inadequate solid waste management, and limited healthcare access, reflecting deliberate policy choices prioritizing predominantly White urban areas.

Indigenous populations demonstrated extreme disparities, with hazard ratios reaching 14.28 for specific mortality outcomes, reflecting cumulative burdens including water contamination from mining, deforestation impacts, mercury exposure, and inadequate sanitation. Limited research focus (11.1%) represents an important gap given substantial Indigenous populations and ongoing territorial threats.

Environmental racism operates through intersecting mechanisms: distributional injustice, procedural injustice, and recognition injustice. Addressing this requires infrastructure investment plus strengthened land tenure security, enhanced political representation, and respect for traditional environmental management.



5.4 URBAN ENVIRONMENTAL RACISM

Urban studies revealed persistent environmental racism affecting predominantly Black neighborhoods and informal settlements, consistently documenting elevated health risks for Black populations, aligning with residential segregation research (Maricato, 2003).

Favelas, housing approximately 13 million Brazilians (predominantly Black and mixed-race), exemplify urban environmental racism. These settlements occupy hazardous areas, including steep slopes, floodplains, and contaminated sites, reflecting structural constraints: housing market discrimination, inadequate planning, and insufficient public investment. Urban environmental racism manifests through differential air pollution exposure, limited green space access, urban heat islands, proximity to waste facilities, and climate-related vulnerability.

5.5 METHODOLOGICAL CONSIDERATIONS AND LIMITATIONS

Substantial heterogeneity reflects fundamental research challenges. Studies varied in population definitions, exposure measurements, outcome assessments, and analytical methods. While capturing environmental racism's multifaceted nature, this complicates synthesis and limits precise quantitative estimates. The decision against formal meta-analyses was methodologically justified, given extreme heterogeneity compromising the reliability of the pooled estimate.

Review limitations include: (1) inclusion since 2017 potentially missing earlier work; (2) single-reviewer approach increasing missed study risk; (3) Portuguese-language source predominance limiting international visibility; and (4) potential publication bias, though consistency across contexts suggests genuine patterns.

5.6 IMPLICATIONS FOR POLICY AND PRACTICE

Priority interventions include: (1) sanitation infrastructure explicitly prioritizing marginalized communities through targeted investments, preferential financing, and monitoring systems with explicit equity metrics; (2) environmental health surveillance incorporating racial/ethnic stratification; (3) environmental licensing including explicit environmental justice consideration; (4) traditional community-specific protections including strengthened land tenure, prioritized infrastructure investment with community participation, enhanced representation in decision-making, and cumulative impact assessment; and (5) integrated urban approaches addressing housing, infrastructure, and environmental quality simultaneously.



5.7 RESEARCH RECOMMENDATIONS

Future research should prioritize: (1) methodological standardization enabling quantitative synthesis through standardized exposure definitions, consistent population operationalization, common health outcome measures, comprehensive confounding control, and transparent reporting following STROBE guidelines; (2) longitudinal designs establishing temporality and examining cumulative impacts; (3) addressing research gaps including industrial pollution and toxic exposures, mental health outcomes, cumulative impacts, intervention research, and climate vulnerability; (4) participatory research engaging affected communities; and (5) interdisciplinary research integrating public health, environmental science, sociology, geography, law, and urban planning perspectives.

5.8 STRENGTHS AND CONTRIBUTIONS

This review provides the first systematic synthesis of environmental racism and health evidence across Brazilian contexts, filling a critical literature gap. Identifying consistent patterns across diverse contexts strengthens confidence that this represents a systematic phenomenon requiring policy attention. Highlighting methodological diversity while identifying standardization opportunities provides future research guidance. Integrating theoretical frameworks with empirical evidence strengthens conceptual understanding. Detailed policy implications provide concrete practitioner and policymaker guidance, translating findings into actionable recommendations.

5.9 FUTURE DIRECTIONS

Environmental racism research in Brazil is at a critical juncture. Substantial research production increases from 2023 onwards suggest growing recognition as a priority area. However, translating evidence into policy action requires continued research investment, methodological refinement, and sustained policymaker and community engagement. Future directions should include expansion to underexamined dimensions (air quality, toxic exposures, climate vulnerability, environmental amenities), intervention research testing strategies, and comparative research examining environmental racism across Latin American contexts. Integration of environmental racism perspectives into mainstream public health and environmental policy remains incomplete. Continued advocacy, evidence generation, and coalition-building across academic, community, and policy sectors will be essential to achieving environmental justice and eliminating racialized environmental health disparity patterns.



6 CONCLUSION

Environmental racism is consistently documented across Brazilian studies, manifesting primarily through inadequate sanitation but extending to industrial pollution and water contamination. Quilombola and Indigenous communities face particularly severe disparities rooted in historical marginalization, land tenure insecurity, and institutional neglect. Urban Black populations experience systematic disadvantage through residential segregation, differential infrastructure investment, and unequal environmental amenities access.

Methodological heterogeneity reflects both environmental racism's multidimensional nature and this research field's nascent state. While limiting quantitative synthesis opportunities, it provides comprehensive evidence that environmental racism operates through distributional injustice, procedural exclusion, and recognition failure. Extreme heterogeneity ($I^2 > 75\%$) highlights urgent standardization needs while preserving attention to contextual variations.

Nevertheless, consistent documentation across diverse contexts provides compelling evidence that environmental racism represents a systematic structural phenomenon rather than isolated incidents, strengthening the case for comprehensive policy intervention as a critical public health and social justice priority.

Addressing environmental racism requires coordinated action across multiple sectors and governance levels: (1) targeted sanitation infrastructure investment with explicit equity metrics; (2) strengthened environmental justice protections in licensing and impact assessment; (3) enhanced community participation in decision-making; (4) racial/ethnic stratification in surveillance systems; and (5) integrated urban interventions addressing housing, infrastructure, and environmental quality simultaneously.

Future research should prioritize methodological standardization, enabling robust quantitative synthesis, longitudinal designs strengthening causal inference, and addressing gaps, including industrial pollution, mental health outcomes, climate vulnerability, and intervention studies. Participatory research approaches would strengthen relevance while building community advocacy capacity.

Research production clustering from 2023 onwards suggests growing recognition as a critical priority. Sustaining momentum requires continued investment in research capacity, methodological innovation, and evidence translation through sustained policymaker and community engagement. Achieving environmental justice demands not only technical interventions but fundamental transformation of political and economic structures perpetuating racialized environmental burden and benefit distribution patterns.



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