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# INEQUALITIES IN ACCESS TO REPERFUSION IN ISCHEMIC STROKE AND THEIR IMPACT ON CLINICAL OUTCOMES: AN INTEGRATIVE REVIEW

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## ABSTRACT

This integrative review examined how inequalities in access to reperfusion for ischemic stroke, through intravenous thrombolysis and mechanical thrombectomy, relate to clinical outcomes. Sixteen publications from PubMed and SciELO, published in the last five years, were included. Findings were grouped into three themes and integrated through narrative synthesis. Studies described differences in reperfusion use by race and ethnicity, socioeconomic status, rural or urban residence, treating hospital and health system. In the Brazilian studies, thrombolysis predominated over thrombectomy and the regional distribution of services was uneven. In some investigations, social position was also associated with functional outcome after treatment. Most studies were observational and conducted in the United States, which limits causal inference and the transfer of findings to Brazil. The results point to the need to strengthen stroke care networks and to monitor access by group and territory.

**Keywords:** Ischemic stroke; Thrombolytic therapy; Thrombectomy; Healthcare disparities; Health services accessibility.

## 1 INTRODUCTION

Ischemic stroke occurs when an artery becomes blocked and blood flow to a region of the brain is interrupted. The affected tissue deteriorates quickly, so the time between symptom onset and treatment weighs heavily on recovery. Reperfusion, meaning the reopening of the vessel, is the treatment that can reduce disability. It is delivered by two main routes: intravenous thrombolysis, which uses drugs that dissolve the clot, and mechanical thrombectomy, which removes the clot with a catheter in large vessel occlusions [1,2].

Both therapies depend on conditions that go beyond the patient: recognizing the symptoms, reaching a hospital with the necessary capacity, obtaining imaging, having a team available and, in the case of thrombectomy, being referred to a center equipped for the procedure. Each of these steps can be more or less accessible depending on where a person lives, their income, their health coverage and the racial or ethnic group to which they belong. When access varies systematically between groups, this is called inequality, not just difference.

Recent literature includes analyses of large databases and hospital registries, mostly from the United States, that describe differences in the use of reperfusion between racial, ethnic and socioeconomic groups and between urban and rural areas [3–5]. In Brazil, studies describe the expansion of these therapies within the Unified Health System (SUS), regional heterogeneity and differences between health systems [1,6,7]. These studies start from different contexts, with distinct financing arrangements and care networks, and this calls for caution when comparing them.

Given these differences, it is worth gathering the studies and considering what they show about access to reperfusion and about the clinical outcomes of people who receive it or go without. This review started from the following question: what inequalities in access to reperfusion for ischemic stroke are described in the literature, and how do they relate to clinical outcomes?

The objective was to investigate these inequalities and describe how they appear, considering racial, ethnic, socioeconomic, geographic and organizational factors. The review also discusses what the findings imply for the organization of stroke care.

## 2 MATERIALS AND METHODS

### 2.1 Study design

An integrative literature review was carried out, with qualitative synthesis of studies of different designs. According to Toronto [8], this method makes it possible to bring together research with varied approaches and to integrate their contributions to the understanding of the topic.

The PICo strategy (population, phenomenon of interest and context) was used to structure the question presented in the introduction, following the components described by Aromataris et al. [9]. The population of interest was people with ischemic stroke; the phenomenon, inequalities in access to reperfusion (intravenous thrombolysis and mechanical thrombectomy) and the associated clinical outcomes; and the context, the health services and systems in which care takes place.

### 2.2 Search strategy

PubMed, with the subset filter "pubmed pmc", and the Scientific Electronic Library Online (SciELO) were searched. The period was limited to the last five years. In PubMed, the search combined controlled vocabulary (Medical Subject Headings, MeSH) and free-text terms in the title and abstract for ischemic stroke and for reperfusion, including thrombolysis, thrombectomy, endovascular therapy and the agents alteplase and tenecteplase. The AND operator linked the two concepts, and OR grouped the alternative terms within each. In SciELO, a third block was added with terms for access, inequality, disparity, barriers and time to treatment, in Portuguese, English and Spanish. The expressions used and the filters applied to each source are shown in **Table 1**.

**Table 1: Search strategies by source consulted**

| Source | Search expression | Filters and procedures |
|---|---|---|
| PubMed | ("Stroke"[Mesh] OR "Ischemic Stroke"[Mesh] OR "Brain Ischemia"[Mesh] OR stroke[tiab] OR strokes[tiab] OR "ischemic stroke"[tiab] OR "ischaemic stroke"[tiab] OR "acute stroke"[tiab] OR "cerebral infarction"[tiab] OR "brain ischemia"[tiab] OR "brain ischaemia"[tiab]) AND | Last 5 years; free full text; humans; article types: case reports, clinical study, clinical trial, comparative study, controlled clinical trial, corrected and republished article, dataset, meta- |

| | | |
|---|---|---|
| | ("Reperfusion"[Mesh] OR "Thrombolytic Therapy"[Mesh] OR "Thrombectomy"[Mesh] OR reperfusion[tiab] OR thrombolysis[tiab] OR thrombolytic[tiab] OR thrombolytics[tiab] OR thrombectomy[tiab] OR thrombectomies[tiab] OR "mechanical thrombectomy"[tiab] OR "endovascular therapy"[tiab] OR "endovascular treatment"[tiab] OR alteplase[tiab] OR tenecteplase[tiab] OR tPA[tiab] OR rtPA[tiab] OR "intravenous thrombolysis"[tiab]) AND "pubmed pmc"[sb] | analysis, observational study, randomized controlled trial and systematic review. |
| SciELO | ("acidente vascular cerebral isquêmico" OR "AVC isquêmico" OR "ischemic stroke" OR "ischaemic stroke" OR "accidente cerebrovascular isquémico") AND (trombólise OR trombectomia OR reperfusão OR thrombolysis OR thrombectomy OR reperfusion OR trombólisis) AND (acesso OR desigualdade OR disparidade OR barreiras OR "tempo de atendimento" OR access OR disparities OR inequality OR barriers OR "time to treatment") | Last 5 years; Brazil collection; title and abstract screening; full text for eligibility. |

**Source:** prepared by the authors, 2026.

### 2.3 Eligibility criteria and study selection process

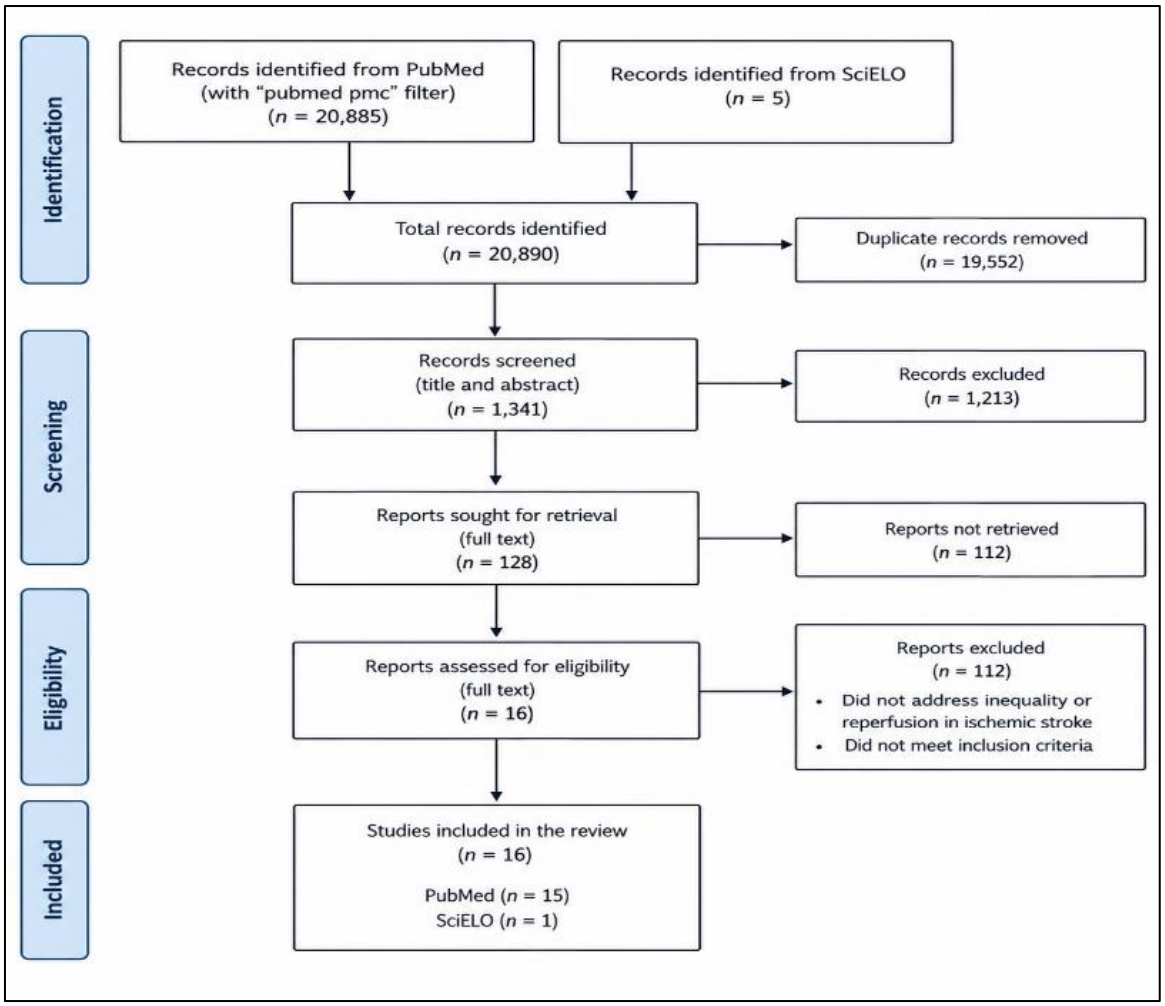
Eligible studies were those published in the last five years, with full text available, conducted in humans, that addressed differences in access to or use of reperfusion in ischemic stroke (intravenous thrombolysis, mechanical thrombectomy or both) between racial, ethnic, socioeconomic or geographic groups, between hospitals or between health systems, or that related these differences to clinical outcomes. Observational studies, trials, reviews and normative documents relevant to the question were accepted. Duplicates and works that did not address inequality or reperfusion in ischemic stroke were excluded.

The numbers of records identified, screened, assessed for eligibility and included from each source are shown in **Figure 1 and Table 2**. In SciELO, records were screened after the country and period filters were applied. The review comprised 16 publications, 15 from PubMed and one from SciELO.

**Table 2: Selection process counts**

| Source | Identified | Screened | Eligibility | Included |
|---|---|---|---|---|
| PubMed | 20,885 | 1,338 | 128 | 15 |
| SciELO | 5 | 3 | 2 | 1 |
| Total included | – | – | – | 16 |

**Source:** prepared by the authors, 2026.




**Source:** Prepared by the authors, 2026.

**Figure 1: PRISMA 2020 flow diagram of the study selection process.**

### 2.4 Data extraction and analysis

The extraction recorded authorship, year, title, design, geographic setting and main results of the 16 publications. The characterization matrix is presented in Table 3, in the results section. For the comparative reading, the type of inequality examined, the reperfusion therapy involved, the clinical outcome assessed and the health system in which the study was conducted were taken into account.

Integration followed Dwyer's guidance [10] for relating results to the characteristics of the studies that produced them. The critical appraisal was descriptive and considered the design, the data source, the possibility of adjusting for confounders and the transferability of the findings to other contexts. No standardized risk-of-bias rating was applied. Given the diversity of outcomes and contexts, a narrative synthesis without meta-analysis was adopted, organized into three themes: race, ethnicity and socioeconomic status; territory, hospitals and health systems; and clinical outcomes, implications and limits of the evidence.

Because this is a literature review, the study did not involve human subjects or animals and did not require approval by an ethics committee.

### 2.5 Use of artificial intelligence tools

A generative artificial intelligence tool (Claude, Anthropic) was used as writing support during the preparation of the manuscript. Its use was restricted to language revision, translation into English, standardization of terminology and formatting, and checking the internal consistency of the text, including the agreement between the counts reported in the text, in Table 2 and in Figure 1.

The research question, the search strategies, the screening and selection of studies, the data extraction, the critical appraisal and the interpretation of the findings were carried out by the authors. Every suggestion produced by the tool

was critically reviewed and accepted, modified or rejected by the authors, and all references were checked against their original sources. The authors take full responsibility for the content of this article. In line with the recommendations of the International Committee of Medical Journal Editors (ICMJE) and the position of the Committee on Publication Ethics (COPE), the tool does not meet authorship criteria and is not listed as an author.

## 3 RESULTS AND DISCUSSION

Sixteen publications were gathered. The set includes analyses of national databases and hospital registries from the United States, regional studies, reviews, a clinical protocol of the SUS and Brazilian studies on the access to and distribution of these therapies. The characteristics of each publication are summarized in **Table 3**. The discussion below distinguishes North American from Brazilian evidence, because the health systems differ and the findings of one do not transfer automatically to the other.

**Table 3: Characteristics of the 16 included publications**

| Author, year [ref.] | Design and setting | Main focus and findings |
|---|---|---|
| Faigle, 2023 [3] | Narrative review; United States | Synthesizes evidence on racial and ethnic differences in the use of thrombolysis and thrombectomy. |
| de Havenon et al., 2021 [4] | Observational study of a national inpatient database; United States | Describes racial, socioeconomic and geographic differences in the use of interventions for acute ischemic stroke. |
| Metcalf and Zhang, 2023 [11] | Observational study; United States | Examines racial and ethnic differences in the use and outcomes of ischemic stroke treatment. |
| Kiefer et al., 2025 [12] | Observational study; United States | Examines racial differences in access to, and outcomes of, acute ischemic stroke treatments. |
| Man et al., 2024 [13] | Trend study of a national registry (2003–2021); United States | Tracks thrombolysis care metrics and outcomes by race and ethnicity. |
| Nguyen et al., 2022 [14] | Observational study; United States | Relates socioeconomic status to long-term functional outcome after thrombectomy. |
| Hagedorn et al., 2025 [5] | Regional study; Colorado, United States | Compares access to thrombectomy for large vessel occlusions between rural and urban areas. |
| Jagolino-Cole et al., 2025 [15] | Observational study; United States | Shows that rural patients transferred for thrombectomy receive catheter-based treatment less often. |
| Daniel, Maillie and Dhamoon, 2024 [16] | Observational study; United States | Analyzes care segregation between hospitals and racial differences in outcomes by hospital region. |
| Lusk et al., 2025 [17] | Observational study; United States | Relates hospital implementation of thrombectomy to equity in acute stroke outcomes. |
| Martins et al., 2022 [6] | Observational study; Brazil | Describes differences in patient-reported outcomes between Brazilian health systems. |
| Martins et al., 2023 [1] | Narrative review; Brazil | Presents an overview of reperfusion therapy in the country, including access limitations. |
| Rocha et al., 2025 [2] | Clinical protocol and therapeutic guidelines of the SUS; Brazil | Sets out recommendations for the diagnosis, treatment and follow-up of acute ischemic stroke in the SUS. |
| Bonfim et al., 2026 [18] | Spatiotemporal analysis; Southern Brazil | Examines hospitalizations, mortality and access to intravenous thrombolysis across the territory. |
| Rosário et al., 2022 [19] | Epidemiological analysis; Brazil | Analyzes stroke patients with emphasis on access to acute-phase therapies. |
| Carvalho et al., 2026 [7] | Ecological time-series study, SUS Hospital Information System (SIH/SUS); Brazil | Describes the use of thrombolysis and thrombectomy in the SUS from 2018 to 2025, with mortality, costs and regional inequalities. |

**Source:** prepared by the authors from the studies included in the review, 2026.

### 3.1 Race, ethnicity and socioeconomic status

The North American studies concentrate the discussion of racial and ethnic inequalities. Faigle's review [3] gathers evidence that Black and Hispanic people received less reperfusion than white people in different analyses across the country, and de Havenon et al. [4], using a national inpatient database, described racial, socioeconomic and geographic differences in the use of acute interventions. Metcalf and Zhang [11] and Kiefer et al. [12] examined both access to treatment and outcomes, which makes it possible to ask whether lower use goes together with worse clinical results.

One relevant finding comes from Man et al. [13], who followed thrombolysis care metrics and outcomes by race and ethnicity from 2003 to 2021. Observation over almost two decades is useful because it shows whether differences persist, narrow or shift as treatment expands, rather than just whether they exist at one point in time. The studies in this theme differ in data source and statistical adjustment, so their figures should not be added together as if they measured the same thing.

These results have to be read with conceptual caution. In observational studies, race and ethnicity act as markers of social circumstances, such as insurance coverage, place of residence, hospital of entry and time to arrival, and not as biological causes of lower use. The association therefore describes where the system fails to reach certain groups, without explaining the mechanism by itself.

Socioeconomic status also matters after treatment. Nguyen et al. [14] associated socioeconomic position with long-term functional outcome after thrombectomy, which indicates that receiving the procedure does not erase the differences: the long-term result may depend on rehabilitation, home support and follow-up, which are also unevenly distributed. This study deals with patients who were already treated and therefore says nothing about those who went without access.

In Brazil, the included studies do not center their analysis on race and ethnicity, and this is a gap in the set. What is found are differences between health systems and between regions. Martins et al. [6] described disparities in patient-reported outcomes between health systems in the country, which brings the discussion closer to coverage status and to the type of service that cares for each person. The Brazilian and North American findings deal with inequalities of a similar nature, but measured along different dimensions, and the absence of national racial data in this review does not allow the conclusion that such inequalities do not exist.

### 3.2 Territory, hospitals and health systems

The second theme gathers the studies in which place of residence and the organization of the network weigh more than patient characteristics. Hagedorn et al. [5] compared access to thrombectomy for large vessel occlusions between rural and urban areas of Colorado, and Jagolino-Cole et al. [15] showed that rural patients transferred for thrombectomy received catheter-based treatment less often. Both works indicate that the problem does not end at arrival at the first hospital: transfer to a higher-complexity center is a step at which access can be lost.

Hospital organization also matters. Daniel, Maillie and Dhamoon [16] analyzed care segregation, that is, the concentration of racial groups in certain hospitals and regions, and the differences in outcomes that accompany this distribution. Lusk et al. [17] examined hospital implementation of thrombectomy and its relationship with equity in outcomes. Read together, the two studies shift the question from the patient to the service: who is treated matters, but so do where and with what installed capacity.

In Brazil, this theme is the best represented. Carvalho et al. [7] described 37,543 hospitalizations with reperfusion in the SUS between 2018 and 2025, of which 96.4% were for thrombolysis and 3.6% for thrombectomy. Thrombectomy first appeared in the records in 2023 and expanded in 2024, and national rates reached 3.22 per 100,000 inhabitants for reperfusion in 2024 and 0.36 per 100,000 for thrombectomy. The authors recorded persistent regional disparities and recommend strengthening stroke networks and speeding up transfers between hospitals. This is an ecological study based on administrative data that covers only SUS care, so it does not describe what happens in the private network, and the 2025 period runs only through August.

The remaining Brazilian studies fit this picture. Martins et al. [1] presented an overview of reperfusion in the country, Bonfim et al. [18] analyzed the spatial and temporal distribution of hospitalizations, mortality and access to thrombolysis in Southern Brazil, and Rosário et al. [19] emphasized access to acute-phase therapies. The SUS protocol [2] is of a different nature: it is a normative document that defines what should be offered, and it serves as a reference for comparing what the network delivers with what the guideline recommends. The gap between the two is exactly where inequality sits.

The asymmetry between the two contexts deserves mention. In the United States, territorial inequality appears mainly as distance to thrombectomy centers in rural areas. In Brazil, the continental dimensions of the country, the

concentration of specialized services and the recent incorporation of thrombectomy into the SUS form a setting of their own, in which the priority pointed out by the studies is the organization of the network and the transfer flow.

### 3.3 Clinical outcomes, implications and limits of the evidence

The relationship between inequality of access and clinical outcome is not direct in the studies gathered. In some of them, lower use of reperfusion goes together with worse outcomes [11,12,16]. In others, the difference persists even among those who received treatment [14], which suggests that access is a necessary but not sufficient condition for equity. There are also studies whose design describes the supply of care rather than the outcome, such as that of Carvalho et al. [7].

The in-hospital mortality data from that study show the caution that is needed. Mortality was 10.6% overall, 10.4% in thrombolysis and 16.3% in thrombectomy. The authors interpret the difference as compatible with indication and severity bias, since thrombectomy is indicated for large vessel occlusions, which are more severe. Higher mortality in this group therefore does not indicate worse performance of the procedure, and crude comparisons between therapies or regions can be misleading when they do not take the patient profile into account.

The implications for care concern mainly the organization of services. The findings support monitoring access to reperfusion by group, territory and type of service, instead of tracking only average rates, which can hide differences. They also support attention to transfers between hospitals, the step at which access was lost in the rural studies, and to rehabilitation and follow-up after treatment, since social position was associated with functional outcome. These ideas are consistent with what the studies describe, but none of them tested interventions to reduce inequality, and the effectiveness of such interventions still needs to be investigated.

The interpretation of the evidence has limits. Observational studies predominate; they allow associations to be recognized but cannot establish causality or the sequence of events. Most of the studies are North American, and their results cannot be transposed to Brazil without considering the differences between health systems. The set ranges from analyses of national databases to narrative reviews and a clinical protocol, which prevents adding up such different information as if it indicated the same thing, and the narrative synthesis served to put the studies in dialogue without erasing their differences, following Dwyer's guidance [10].

Limitations of the review process add to these. The PubMed search was restricted to the free full-text subset and to the last five years, which may have left out relevant studies; the SciELO search, limited to Brazil, returned few records; no standardized risk-of-bias rating was applied; and no protocol was registered in advance for the selection. These conditions limit the scope of the review and the strength of its conclusions.

Future research could examine, with national data, racial, ethnic and socioeconomic inequalities in access to reperfusion in Brazil, which are currently little represented, and follow patients after discharge to assess functional recovery by social position. Studies that evaluate interventions on the network, such as transfer protocols and telemedicine, with comparison groups, could show which strategies reduce inequality and under what conditions.

## 4 CONCLUSION

Access to reperfusion in ischemic stroke is not evenly distributed. The differences described relate to race and ethnicity, socioeconomic status, place of residence, hospital and health system, and in some of the studies they go together with worse outcomes. In Brazil, the recent incorporation of thrombectomy into the SUS and the persistence of regional disparities place the organization of care networks and of transfers between hospitals at the center of the discussion.

For practice, the results offer reference points for monitoring access by group and territory and for attending to critical steps such as transfer and rehabilitation. The conclusions are bounded by the predominance of observational and North American studies, the scarcity of Brazilian racial data and the limitations of the selection process. Future research can fill these gaps and evaluate strategies to make reperfusion accessible to everyone who needs it.

## STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

### *Statement of ethical approval*

This study is an integrative literature review based exclusively on previously published data and did not involve human participants or animals; therefore, approval by an ethics committee was not required.

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