Geographic accessibility to hospital childbirths in Brazil (2010–2011 and 2018–2019): a cross-sectional study

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Summary

Background Delays in obstetric care are associated with adverse maternal outcomes, while long-distance travel for delivery is associated with high neonatal mortality and increased maternal morbidity. Distance and travel time are key components of geographic accessibility to health services and important risk indicators for maternal and neonatal care. This study evaluated whether the Brazilian Unified Health System (SUS) has been geographically accessible in providing hospital childbirth services, over time.

Methods Geographic accessibility to hospital deliveries in Brazil was mapped over two biennia (2010–2011 and 2018–2019), spanning a 10-year period, using national aggregated data from SUS Hospital Admissions Authorizations. Travel flows, distances, and times between women's municipalities of residence and hospitals were estimated.

Findings A total of 6,930,944 hospital deliveries were analyzed. Overall, 25.4% (n = 1,759,306) of pregnant women traveled outside their municipalities to give birth in SUS hospitals, increasing from 23.6% (n = 843,501) in 2010–2011 to 27.3% (n = 915,805) in 2018–2019. Distance and travel time rose by 31.1% (54.0 km–70.8 km) and 33.6% (63.1–84.3 min), respectively. Women experiencing maternal and/or neonatal death traveled longer distances and times. Regional disparities were evident: the Northeast had the highest proportion of women traveling (35.6%; n = 817,499), and the North had the lowest (16.0%; n = 138,295). Women in the North faced the longest travel distances (97.5–133.4 km) and times (1,012–1,850 min), while those in the Southeast and South experienced the shortest distances (37.2–55.9 km and 41.2–54.8 km, respectively) and times (38–52 min and 41–52 min).

Interpretation The results highlight regional disparities in maternal health service access within the SUS, which may affect maternal and neonatal outcomes. Targeted public health measures are needed to improve the availability of service, particularly in the North and Northeast regions, where access issues are most severe.

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Keywords: Maternal health services; Hospital deliveries; Health services accessibility; Geographic accessibility; Brazil; Travel distance; Health equity

Introduction

In Brazil, 98% of deliveries take place in hospitals, of which 77% are within the Brazilian Unified Health System (Sistema Único de Saúde—SUS, in Portuguese).[1] Timely hospital delivery is critical to maternal safety and quality of care. Nonetheless, geographic differences in access to obstetric care suggest gaps in the SUS that require most pregnant women to travel from one municipality to another for adequate care.[2]

The SUS is a tax-funded, universal healthcare system, that assists approximately 75% of the Brazilian population. The system is divided into health regions as microcosms of the national system to integrate the organization and planning of health services and interventions.[3]

Expanding access to the SUS is one of the main challenges of health managers.[4] Geographic accessibility is one of the factors in assessing public health services

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Translation: For the Portuguese translation of the abstract see the Supplementary Materials section.

Research in context

Evidence before this study

We conducted a comprehensive search of international (Scopus and PubMed) and regional (SciELO) databases for studies on geographic accessibility to hospital childbirths in Brazil published between 2012 and 2022. The search targeted titles and abstracts using the query: Brazil AND (accessibility OR distance) AND (childbirth OR delivery). Of the 44 studies retrieved, only three specifically examined geographic accessibility to childbirth in Brazil. Two of these studies focused on specific locations: one in the state of Bahia and the other in the city of São Paulo. The study in Bahia explored access to normal childbirth, while the São Paulo study analyzed clusters of live births within the city. Only one study examined national-level distances for childbirth, investigating the relationship between infant mortality rates and geographic access to childbirth services across Brazilian municipalities, though it covered only a short period (2005–2007). Notably, none of the studies analyzed geographic accessibility patterns over time.

Added value of this study

Our study's novelty lies in its extensive temporal scope and its focus on regional disparities across the entire country, providing a comprehensive analysis of the geographic accessibility of hospital childbirth under the Brazilian Unified Health System (SUS). By examining national data from two distinct periods (2010–2011 and 2018–2019) spanning 10 years, we offer a longitudinal perspective that was previously lacking. This approach allowed us to identify changes in travel distances and times for hospital deliveries, providing valuable insights into the evolving landscape of maternal healthcare accessibility in Brazil. By mapping travel networks and analyzing the distance and time traveled by pregnant women to reach SUS hospitals, we uncover critical regional inequalities and their impact on maternal and neonatal outcomes.

Implications of all the available evidence

Our study highlights regional disparities in access to hospital childbirth services in Brazil, emphasizing the need for targeted policy measures to improve the distribution and accessibility of obstetric services in underserved regions, particularly the Northeast and North. Policymakers should revise the allocation of obstetric beds to better reflect regional needs and improve transportation infrastructure to reduce travel times. These efforts are essential to ensure equitable healthcare access for all pregnant women and to enhance maternal and neonatal health outcomes.

and has been used in other countries to evaluate universal health coverage.[5,6] It reflects the spatial distribution of health services and expresses whether these services adequately meet the users' needs, considering distance, means of transportation, and travel times.[7] Geographic accessibility is, thus, an important factor related to service use, a relevant dimension in health equity.[8]

Delays in obstetric care are associated with poor maternal outcomes,[9] while long traveling for delivery has been associated with higher infant[10] and neonatal mortality[11] and higher risk of maternal morbidity and mortality.[12] Although Brazil has implemented strategies, such as the Stork Network (Rede Cegonha, in Portuguese),[13] to ensure access to obstetric care, there is limited evidence of travel distances and/or times to reach hospitals for delivery, and no indicators to monitor trends in access to hospital childbirth. A recent study showed marked regional inequalities in access to hospital childbirth in the state of Rio de Janeiro, which persisted for a decade. Intercity travel for childbirth has increased, with notable differences in travel times and distances across health regions.[14] Therefore, travel distance and time to hospital for delivery are useful surrogate risk indicators for maternal and newborn care.

In this study, geographic accessibility represents the physical distance and road travel time between the user's municipality of residence and the municipality of service provision. The aim of this study was to evaluate whether the SUS has been geographically accessible in providing hospital childbirth services to pregnant women in Brazil, over time. Travel flows, distance, and travel time for pregnant women who delivered at a SUS hospital were estimated over two biennia (2010–2011 and 2018–2019), spanning a 10 year-period.

Methods

The study used data from the biennia 2010–2011 and 2018–2019, to represent two distinct phases of maternal and child healthcare as defined by Regulation n. 1459/2011 of the Ministry of Health (MoH), which established the Stork Network.[13] The regulation brought about important changes in the understanding and organization of maternal and child care focusing on prenatal care, labor and delivery, the postpartum period, and logistic systems, including health transportation and regulation.

This study was exempt from ethics review because it used only secondary, administrative, public, and aggregated data from DATASUS without individual identification.

Source of data

The Department of Information Technology of SUS (DATASUS) maintains National Health Information Systems, which collect data on various aspects of the Brazilian population, including morbidity and mortality,

health services, and administrative and financial data. Among these systems, the SUS Hospital Information System, developed in the 1990s, serves as the primary source of hospitalization data for the Ministry of Health (MoH). It supports managers in planning, controlling, billing, and auditing healthcare services. Hospital data from all 5,570 Brazilian municipalities are registered in this system, which is updated monthly with information on patients and services provided. Almost all births in Brazil occur in hospitals, with 60–70% taking place in SUS-accredited hospitals, all recorded within the SUS Hospital Information System.[15] The system has also been widely used to support retrospective health research.[16]

Data extraction, processing, and validation

The analysis included the entire population that met the inclusion criteria: low-risk deliveries in SUS hospitals, which account for approximately 60–70% of all deliveries in Brazil when considering those in private hospitals and high-risk deliveries at SUS. Data on hospital deliveries for low-risk pregnancies were extracted from the SUS Hospital Information System using Hospital Admission Authorization records, ensuring comprehensive coverage of all eligible cases. By focusing exclusively on SUS data and including the total eligible population, the study minimizes selection bias, enhances the reliability of the results, and provides robust and representative findings to support improvements in public maternal healthcare policies.

The SUS Hospital Information System was accessed through the Platform for Data Science Applied to Health (PCDaS) of the Institute of Scientific and Technological Communication and Information in Health (ICICT/Fiocruz). A dataset was created using the Python language, applying the following filters: i) Year of hospitalization: 2010, 2011, 2018 and 2019; ii) Procedure: codes 411010034 for cesarean delivery; and 310010039 for vaginal delivery; iii) Women age: 10–49 years; iv) Municipality of residence; v) Municipality of hospitalization; vi) Hospital discharge reason. Records missing any of these variables were not extracted to ensure data completeness. The number of Hospital Admission Authorizations was used as a proxy for the number of pregnant women. The total dataset included 1,801,124 hospital deliveries in 2010, 1,776,007 in 2011, followed by 1,689,327 in 2018, and 1,664,486 in 2019. Most deliveries occurred in medium- and high-complexity maternity or general hospitals.

Travel network assembly, visualization, and analysis

The unit of analysis was the women's residential municipality (origin) and the hospital municipality (destination). Only records in which the municipality pair was different, indicating intercity travel, were included. A pair of origin/destination municipalities defined a connection and the number of women traveling between them established a flow. Links between municipalities are directional (from origin to destination) and asymmetric (non-reciprocal) and were weighted by the number of women traveling between each pair of municipalities. Network visualizations were created in Gephi 0.9.2 (www.gephi.org).

Distance and travel time estimates

Distance and time were selected as key variables to ensure a comprehensive analysis of accessibility. Distance offers a straightforward, quantifiable measure of the geographic separation between municipalities, while travel time is a more practical indicator of the mobility experience.

Estimates of road distances and travel times between the origin and destination municipalities were obtained through the OpenStreetMap Project's Open Source Routing Machine version 3.0.1 software package (www.openstreetmap.org). These measurements were based on the shortest or fastest route between the centroids of each municipality, using car travel model. The Open Source Routing Machine considers various factors such as road types, speed limits, traffic regulations, and other factors embedded in OpenStreetMap's data to determine the most efficient route. While these estimates are consistent, they do not account for real-time traffic conditions or historical data, representing the best-case scenario. Any deviations from this would suggest that actual travel conditions during the study period were likely less favorable.

Weighted average distances and travel times were calculated by adding travel distance/time between origin/destination municipalities multiplied by the number of women traveling between the two municipalities, divided by the total number of women who traveled for delivery. The weighted average was used to compare intercity flows more accurately by considering the number of deliveries associated with each route. This ensured a more realistic estimate of access to obstetric care, giving more weight to routes with higher usage and preventing distortions from simple averages, which treat all routes equally. No weighting was applied for the assessment of travel distance/time and adverse birth outcomes. In analyses by region, estimates of distance and travel time for cesarean and vaginal deliveries were pooled.

Statistical analysis

Normality was evaluated using graphical methods (histograms and boxplots), given the large dataset. Once the data distribution was confirmed to approximate normality, a two-proportion Z-test was used to analyze differences in the proportions between the two-year periods. Additionally, two-sample t-tests were performed to compare the weighted average distance and

travel time between the periods and to examine their associations with adverse birth outcomes (maternal and/or newborn death). Homogeneity of variance was checked for all analyses, and if violated, Welch's t-test was applied. A 5% significance level (two-sided) was used for all statistical analyses.[17]

The association between travel distance/time and adverse birth outcomes was estimated based on the assumption that longer distances/times would be risk factors for maternal and/or newborn deaths. All deliveries associated with a death outcome (see below) were grouped and the two-sample t-test was used to assess the difference between the average distance/time. Hospital discharges associated with a death outcome were filtered: discharge of the mother/postpartum woman and death of the newborn, discharge of the mother/postpartum woman with fetal death, death of the pregnant woman and the conceptus, death of the mother/postpartum woman and discharge of the newborn, and death of the mother/postpartum woman and stay of the newborn. Three other hospital discharge groups were also included: death certificate provided by the attending physician, death certificate provided by the Forensic Medical Institute, and death certificate provided by the Death Verification Service. Statistical analysis was performed using the Minitab Statistical Software v.20 (Minitab Inc, State College, PA, USA) and the segmented packages of the R software, version 3.5.1 (http://www.r-project.org). We followed STROBE reporting guidelines (see Supplementary Table S1).

Ethics committee approval

This study used only secondary, administrative, public, and aggregated data from DATASUS, which does not identify individuals and, therefore, was exempted from appreciation, registration, evaluation and approval by the Brazilian National Health Council (CEP-CONEP system) according to Article 1 of Resolution 510/2016.

Role of funding sources

Funders had no role in the design of the study, data collection, analysis, interpretation of data, or in writing the manuscript.

Results

A total of 6,930,944 hospital deliveries were analyzed: 4,298,463 vaginal births (62%) and 2,632,481 cesarean deliveries (38%). Between 2010 and 2011, a total of 2,322,357 vaginal deliveries (65%) and 1,254,774 cesareans (35%) were recorded (Fig. 1). Between 2018 and 2019, the number of vaginal deliveries decreased by 14.9% (from 2,322,357 to 1,976,106), while the number of cesarean deliveries increased by 9.7% (from 1,254,774 to 1,377,707) (Fig. 1a).

During the two periods analyzed, 25.4% (n = 1,759,306) of pregnant women left their residential municipalities to give birth in a SUS hospital (Fig. 1b). A slight increase was observed over the two biennia: from 23.6% (n = 843,501) to 27.3% (n = 915,805) (proportion difference: −0.037, 95% CI [−0.0379; −0.0366], p-value <0.0001), corresponding to 72,304 more women traveling in 2018–2019 (Fig. 1b). Although the proportional change is small, it indicates a potentially increasing challenge in ensuring access to obstetric care. Women who had cesarean sections were more likely to travel between cities than those who had vaginal births (Fig. 1b).

Analysis by region found that the proportion of women who traveled to give birth varied by region and state of residence. Overall, the Northeast had the highest proportion of women who left their residential municipality to give birth in SUS (35.6%, n = 817,499), while the North had the lowest proportion (16.0%, n = 138,295) (Table 1).

Sergipe had the highest proportion of women who left their home city to give birth (62.2%, n = 58,289), while Amazonas had the lowest proportion (2.8%, n = 5,866) (Table 1). This pattern persisted in the first and second biennium analyzed.

The travel network for delivery is shown in Fig. 2. Each circle represents a municipality, and the connection between them represents the origin/destination flow. The regions are differentiated by colors. During this period, intercity travel flow increased by 25.9% (from 18,433 to 23,213 links between municipalities; p-value <0.0001) for cesarean deliveries and 25.8% (from 20,576 to 25,891 links between municipalities; p-value <0.0001) for vaginal births. Most trips correspond to the boundaries of health areas, with a slight increase between the two periods: from 6.2% to 6.8%.

Over time, the travel distance and time increased by 31.1% and 33.6% (p-value <0.0001), respectively (Fig. 3). Travel distance weighted average increased from 54.0 to 70.8 km, while time from 63.1 to 84.3 min (p-value <0.0001). Vaginal and cesarean deliveries presented similar distance and travel time patterns (Fig. 3).

During both two-year periods, women who experienced adverse birth outcomes (maternal and/or neonatal death) had longer travel distances and times. Specifically, in 2010–2011, women with adverse birth outcomes traveled an average of 75.8 km/82.7 min, while women with normal birth outcomes traveled an average of 56.7 km/64.6 min. In 2018–2019 women with adverse birth outcomes traveled 94.0 km/100.9 min, while women with normal birth outcomes traveled 74.9 km/85.0 min (Supplementary Table S2).

There was a marked regional difference in distance and travel time for delivery. The lighter-colored area in the map represents shorter travel distances (Fig. 4) and times (Fig. 5). The comparison over time shows increasing distances and travel times in most states across the country.

During both two-year periods, women in the North traveled longer distances (97.5–133.4 km) and times

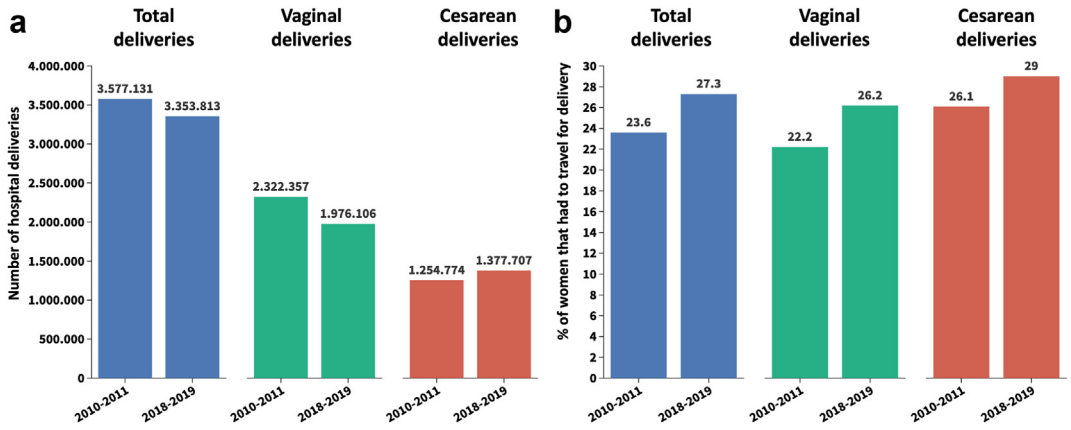

Fig. 1: Total deliveries at SUS hospitals (a), and proportion of women traveling to deliver (b) (2010–2011 and 2018–2019).

Region/state of residence	Total		2010–2011		2018–2019	
	Number of women who traveled	%	Number of women who traveled	%	Number of women who traveled	%
North	**138,295**	**16.0%**	**66,259**	**15.1%**	**72,036**	**16.4%**
Acre	6892	17.9%	3525	15.8%	3367	20.8%
Amazonas	5866	2.8%	2186	2.2%	3680	3.3%
Amapá	6820	14.2%	2648	11.6%	41,72	16.5%
Pará	71,243	17.2%	34,777	16.0%	36,466	18.4%
Rondônia	9868	17.2%	4227	15.4%	5641	18.9%
Roraima	5441	27.0%	2437	26.3%	3004	27.6%
Tocantins	32,165	44.9%	16,459	41.4%	15,7	49.4%
Northeast	**817,499**	**35.6%**	**413,709**	**33.6%**	**403,790**	**32.8%**
Alagoas	76,450	45.4%	39,481	44.7%	36,969	46.1%
Bahia	164,850	27.7%	88,561	27.2%	76,289	28.2%
Ceará	92,859	26.9%	42,229	22.7%	50,630	31.8%
Maranhão	76,572	23.4%	31,172	18.7%	45,400	28.1%
Paraíba	78,723	50.8%	42,131	49.4%	36,592	52.4%
Pernambuco	148,312	44.9%	78,557	44.0%	69,755	46.1%
Piauí	63,833	42.5%	32,995	40.0%	30,838	45.4%
Rio Grande do Norte	57,611	5.4%	27,279	40.4%	30,332	51.1%
Sergipe	58,289	62.2%	31,304	61.6%	26,985	63.0%
Midwest	**97,229**	**22.7%**	**40,420**	**19.7%**	**56,809**	**27.7%**
Goiás	59,022	31.3%	24,258	27.6%	34,764	34.5%
Mato Grosso do Sul	10,621	9.6%	4280	7.6%	6341	11.6%
Mato Grosso	27,586	21.5%	11,882	19.6%	15,704	23.2%
Southeast	**480,711**	**20.3%**	**225,979**	**18.8%**	**254,732**	**21.2%**
Espírito Santo	39,460	31.4%	20,903	32.4%	18,557	30.3%
Minas Gerais	182,512	29.9%	92,189	27.9%	90,323	32.2%
Rio de Janeiro	79,778	19.1%	29,869	15.9%	49,909	21.6%
São Paulo	178,961	14.8%	83,018	13.4%	95,943	16.2%
South	**225,268**	**26.1%**	**97,086**	**22.1%**	**128,182**	**29.2%**
Paraná	81,525	24.6%	31,090	18.1%	50,435	31.7%
Rio Grande do Sul	76,548	23.0%	35,791	21.5%	40,757	24.5%
Santa Catarina	67,195	33.6%	30,205	30.0%	36,990	37.3%

Table 1: **Number of women who left their municipality of residence to give birth, by region and Brazilian state of residence.**

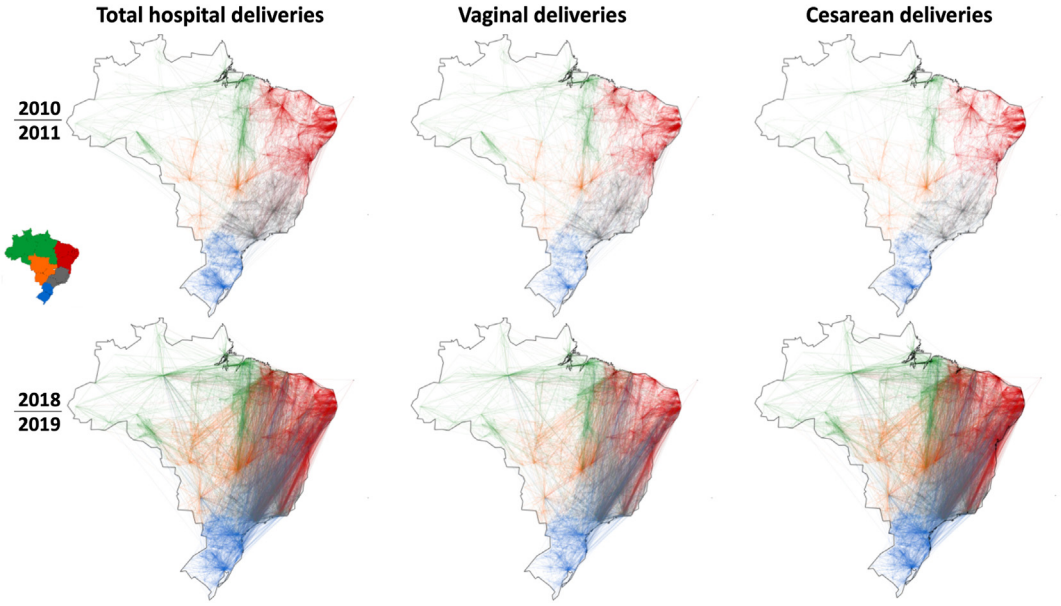

Fig. 2: Travel network for childbirth at a SUS hospital. Each node represents a municipality, and a connection between them represents the origin/destination flow. The links are colored according to the region of residence: North = green; Northeast = red; Southeast = gray; Midwest = orange; South = blue.

(1,012–1,850 min) to give birth in a SUS hospital. In the Southeast and South, the distances and times were shorter (37.2–55.9 km and 41.2–54.8 km, and 38–52 min and 41–52 min, respectively) (Table 2).

Amazonas was the state where women traveled the longest distance: 228.3 km in the first biennium and 291.5 km in the second biennium. The farther the distance, the longer the travel time to reach a hospital in Amazonas, increasing from 1,012 min in 2010–2011 to 1,850 min in the subsequent period (p-value <0.0001). Residents of Rio de Janeiro traveled the shortest distance and time to deliver, estimated at 24.8 km/24 min in 2010–2011, and 37.6 km/35 min in 2018–2019 (p-value <0.0001) (Table 2).

Except for Acre, Amapá, and Roraima, distances and travel times have increased significantly over time in all Brazilian states (Table 2). The largest percentage increases were observed for women living in São Paulo and Mato Grosso, with distance increasing by 109% (from 30.6 km to 64.1 km) and 91% (from 69.4 km to 132.3 km), respectively, and time by 83% (from 30 to 55 min) and 80% (from 70 to 127 min) (p-value <0.0001).

It's important to note that although statistically significant increases in the distances traveled and travel

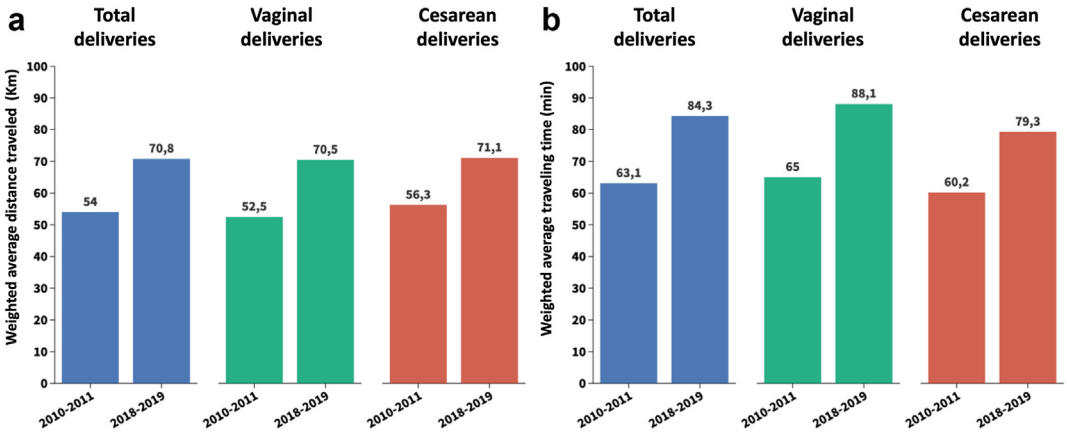

Fig. 3: Weighted average distance (a) and time (b) traveled from home to a SUS hospital to give birth (2010–2011 and 2018–2019).

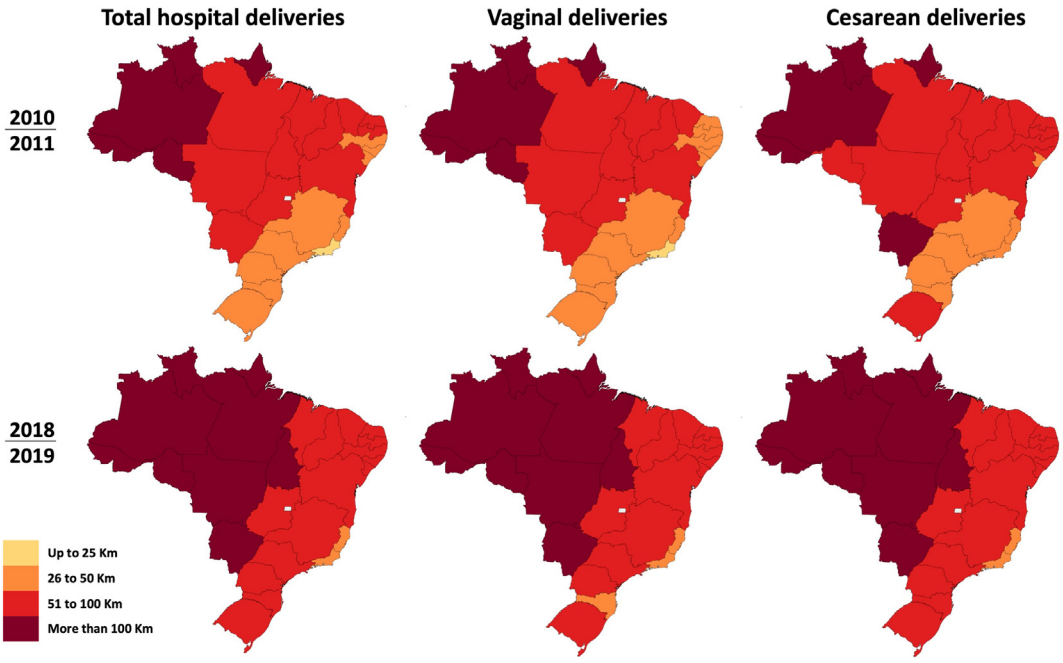

Fig. 4: Distances traveled from home to a SUS hospital for childbirth (2010–2011 and 2018–2019). The average distance between origin and destination was weighted by the number of women traveling between them. The distance from home to hospital was grouped as: up to 25 km, 26–50 km, 51–100 km, and more than 100 km.

times were observed in most states, some of the absolute differences (e.g. 2.8 km/2 min in Alagoas and 6.7 km/6 min in Rio Grande do Sul) are relatively small and may not translate into meaningful practical implications for most pregnant women. While statistical significance reflects the reliability of these findings in the context of

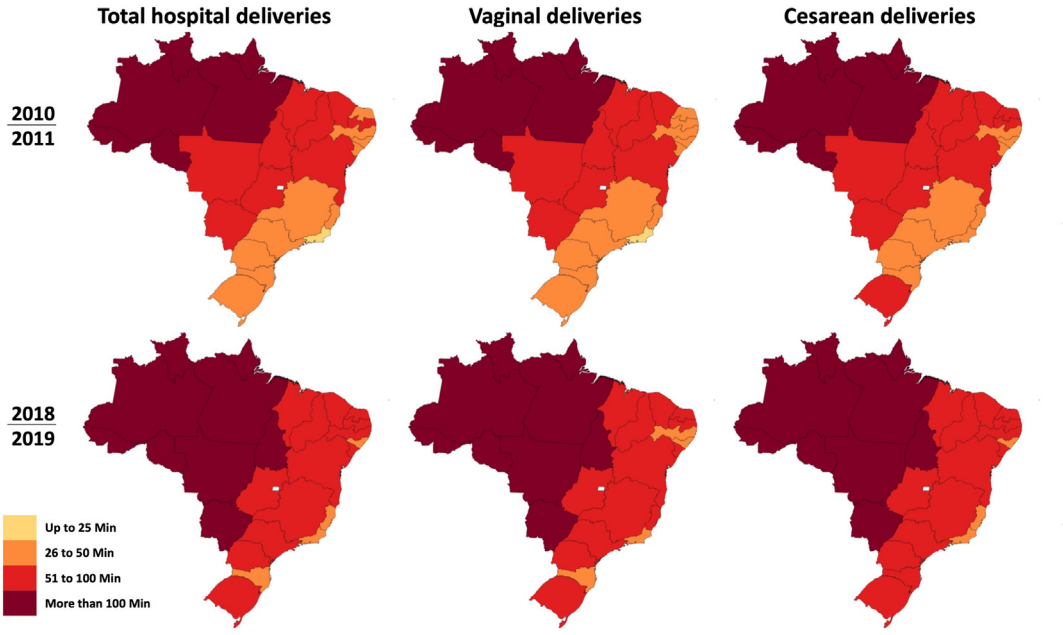

Fig. 5: Travel time from home to a SUS hospital for childbirth (2010–2011 and 2018–2019). The average travel time between origin to destination was weighted by the number of women who traveled between them. The travel time from home to the hospital was grouped as up to 25 min, 26–50 min, 51–100 min, and more than 100 min.

Region/state	Distance traveled (km)				Travel time (min)			
	2010–2011	2018–2019	Percentage change [95% CI]	p-value	2010–2011	2018–2019	Percentage change [95% CI]	p-value
North	**97.5**	**133.4**	**37% [0.364, 0.371]**	**<0.0001**	**233**	**355**	**52% [0.516, 0.524]**	**<0.0001**
Acre	110.8	103.3	−7% [−0.061, −0.078]	0.28	120	115	−4% [−0.033, −0.046]	0.47
Amazonas	228.3	291.5	28% [0.261, 0.293]	<0.0001	1,012	1,850	83% [0.813, 0.848]	<0.0001
Amapá	104.0	112.3	8% [0.071, 0.089]	0.081	148	168	13% [0.123, 0,146]	0.14
Pará	85.4	123.0	44% [0.435, 0.445]	<0.0001	287	381	33% [0.321, 0.331]	<0.0001
Rondônia	103.4	119.3	15% [0.143, 0.164]	0.001	111	130	17% [0.159, 0.181]	<0.0001
Roraima	174.4	184.2	6% [0.047, 0.065]	0.12	196	353	80% [0.783, 0.813]	<0.0001
Tocantins	89.0	127.9	44% [0.429, 0.445]	<0.0001	91	126	38% [0.376, 0.391]	<0.0001
Northeast	**57.2**	**68.6**	**20% [0.200, 0.202]**	**<0.0001**	**54**	**65**	**19% [0.191, 0.193]**	**<0.0001**
Alagoas	49.9	52.7	6% [0.053, 0.057]	<0.0001	46	48	4% [0.036, 0.04]	0.001
Bahia	65.0	81.8	26% [0.254, 0.260]	<0.0001	61	76	25% [0.243, 0.249]	<0.0001
Ceará	54.7	63.2	15% [0.151, 0.157]	<0.0001	54	61	13% [0.129, 0.136]	<0.0001
Maranhão	59.2	76.5	29% [0.288, 0.297]	<0.0001	64	80	25% [0.247, 0.256]	<0.0001
Paraíba	52.0	63.1	21% [0.208, 0.216]	<0.0001	51	61	18% [0.172, 0.179]	<0.0001
Pernambuco	49.9	56.9	14% [0.138, 0.143]	<0.0001	45	51	13% [0.128, 0.133]	<0.0001
Piauí	85.0	97.5	15% [0.143, 0.151]	<0.0001	78	91	17% [0.163, 0.171]	<0.0001
Rio Grande do Norte	52.0	67.6	30% [0.294, 0.305]	<0.0001	50	62	25% [0.247, 0.257]	<0.0001
Sergipe	45.4	56.6	24% [0.240, 0.250]	<0.0001	44	54	21% [0.209, 0.219]	<0.0001
Midwest	**73.7**	**104.4**	**42% [0.412, 0.421]**	**<0.0001**	**70**	**95**	**37% [0.367, 0.376]**	**<0.0001**
Goiás	72.4	86.5	19% [0.190, 0.199]	<0.0001	68	79	17% [0.161, 0.169]	<0.0001
Mato Grosso do Sul	92.9	133.3	43% [0.421, 0.448]	<0.0001	80	111	39% [0.374, 0.400]	<0.0001
Mato Grosso	69.4	132.3	91% [0.901, 0.911]	<0.0001	70	127	80% [0.796, 0.809]	<0.0001
Southeast	**37.2**	**55.9**	**50% [0.499, 0.503]**	<0.0001	**38**	**52**	**38% [0.375, 0.378]**	<0.0001
Espírito Santo	34.9	45.4	30% [0.296, 0.309]	<0.0001	40	50	25% [0.246, 0.259]	<0.0001
Minas Gerais	47.7	59.4	24% [0.241, 0.246]	<0.0001	48	58	20% [0.197, 0.202]	<0.0001
Rio de Janeiro	24.8	37.6	52% [0.514, 0.524]	<0.0001	24	35	44% [0.438, 0.448]	<0.0001
São Paulo	30.6	64.1	109% [1.088, 1.092]	<0.0001	30	55	83% [0.828, 0.833]	<0.0001
South	**41.2**	**54.8**	**33% [0.332, 0.337]**	<0.0001	**41**	**52**	**26% [0.259, 0.264]**	<0.0001
Paraná	43.4	57.6	33% [0.322, 0.331]	<0.0001	42	53	25% [0.247, 0.256]	<0.0001
Rio Grande do Sul	48.5	55.2	14% [0.135, 0.142]	<0.0001	49	55	11% [0.108, 0.115]	<0.0001
Santa Catarina	30.2	51.1	69% [0.688, 0.698]	<0.0001	31	48	56% [0.552, 0.563]	<0.0001

Table 2: **Weighted average distance and travel time to give birth at SUS hospitals for the periods 2010–2011 and 2018–2019, with percentage changes and 95% confidence intervals [95% CI].**

the data, practical relevance requires considering whether the observed changes meaningfully affect accessibility. It is possible that a few additional kilometers or minutes may not impact women's ability to access obstetric services, especially if transportation infrastructure is adequate.

Discussion

During the study period, more than 1.5 million pregnant women (25.4% of all SUS hospital deliveries) traveled outside their municipalities to deliver. This finding is important as it provides a benchmark for assessing future improvements in maternal healthcare access. The distance and travel time experienced by women increased over time, with those whose childbirth resulted in maternal and/or neonatal death facing longer journeys. Regional disparities were notable: the Northeast had the highest proportion of women traveling for childbirth, while the North had the lowest. However, women in the North faced the longest travel distances and times, in contrast to those in the Southeast and South, who traveled the shortest distances and for the least amount of time.

The National Policy for Comprehensive Health Care for Women (Política Nacional de Atenção Integral à Saúde das Mulheres—PNAISM) and the Stork Network (restructured as Rede Alyne in September, 2024) have established guidelines to promote proper access to a regionalized obstetric network. While these policies aim to reduce travel distance, they do not set specific benchmarks for acceptable travel.

Travel may be necessary, especially for high-risk pregnancies or specialized care, often for women living in rural areas. The higher proportion of travel among women who had a cesarean delivery may relate

to the requirement for a higher level of care that is not available in small municipalities. Multiple factors can influence a woman's decision to travel for childbirth, including the availability and perceived quality of services, proximity to family, and local infrastructure. Women may choose to travel further if they expect to receive better quality of care elsewhere or if local options are limited.[18] This stresses that geographical proximity does not always guarantee the use of local services.

The fact that most travel takes place within the MoH health regions suggests that the organization of maternity services has been well-planned and able to meet the demand. However, the results of this study indicate that access to these services has not improved in the past decade, as the proportion of women traveling as well as the travel times and distances have increased. The organization of health regions is important to ensure access to health services, however, their design does not guarantee easy access to these services.[19]

Long journeys to the hospital for delivery are part of the "three delays" model designed to assess access to emergency obstetric care.[20] Whether due to inadequate distribution of health services, long distances, or lack of transport infrastructure, delays in service accessibility (phase II delay), highlight the fact that time to appropriate care is the most important factor associated with maternal mortality.[20] Delivery distance is an important issue in low- and middle-income countries (LMICs), especially in rural areas.[21–23] The hindering effect of distance is stronger when transportation is inaccessible and road conditions are poor.[21] Even if a hospital is conveniently located, it will not be fully utilized if the quality is not considered good. When women have to choose between multiple facilities, they sometimes choose to travel farther if the destination facility offers better quality of care.[24]

Women with adverse birth outcomes traveled longer distances and for longer periods. This suggests that travel distance and time may be potential risk factors for mothers and newborns, though confounding factors, such as existing health status, hospital infrastructure or access to prenatal care, could also have influenced these outcomes. Although this study only included data on low-risk pregnancies, there is a possibility that pregnant women with pre-existing health risks may be forced to travel long distances to find appropriate medical facilities. Well-equipped hospitals with adequate infrastructure, such as neonatal intensive care units (NICUs), and essential medical equipment, are crucial for managing complications during delivery. Inadequate infrastructure can delay or limit access to life-saving interventions. Regular prenatal care enables the early detection and management of conditions such as gestational diabetes, preeclampsia, and infections, reducing the likelihood of complications at birth. Without adequate access to prenatal care, these conditions may go unnoticed, leading to higher risks of adverse outcomes. The use of multivariate techniques in future analyses will be key to better understanding how different factors interact and contribute to adverse maternal and neonatal outcomes. Of note, although mortality information is specifically recorded in the Brazilian Mortality Information System (SIM), a recent study suggests that the SUS Hospital Information System can serve as a complementary information system for studies of maternal mortality and morbidity.[25]

The Stork Network links pregnant women to a specific maternity hospital during pregnancy, thereby reducing their pilgrimage during childbirth.[13] However, establishing a homogeneous care network in heterogeneous regions is a major challenge. The results presented here suggest that the allocation and/or provision of obstetric services may not meet the needs of pregnant women. Challenges faced in Brazil in implementing policies to reduce the distance to delivery services include political and administrative issues, lack of integration of primary healthcare, and inequalities in healthcare services.[26,27] A study, conducted from the women's perspective, found that lack of information and communication, inadequate infrastructure, and lack of human resources were potential obstacles to implementing the National Childbirth Guidelines.[28] There is no empirical evidence to establish appropriate distance standards for hospital delivery. Current regulations stipulate a rate of 0.28 obstetric beds per 1,000 SUS-dependent population, although there are regional differences in age structure, fertility rates, and hospital or home delivery practices.[29] The Alyne Network intends to expand access to maternity services by constructing new maternity hospitals, prioritizing regions with the highest maternal mortality rates.[30] The initiative also focuses on integrating healthcare services between Family Health Units and maternity hospitals, improving coordination for timely maternal care and reducing the need for travel.

The regional disparities observed reveal important inequalities in access to obstetric services across Brazil, highlighting variations in how these services are provided between different regions and states. The longer distances and higher travel times for women in the Northeast and North regions underscore the limitations of the Brazilian health system in addressing these inequalities in obstetric care. Previous studies have also demonstrated that geographic accessibility to hospital deliveries is influenced by factors such as socioeconomic status, population size, and the municipality of residence, with travel distances generally decreasing as per capita income and population size increase.[10]

When analyzing travel distances by region, it is important to consider that in the Midwest and North, many municipalities cover vast rural areas where a community or town can be more than 100 km from the municipal headquarters (where central health facilities are often located). In contrast, in the Southeast, South,

and parts of the Northeast, traveling the same distance often means crossing multiple municipalities. The difference between states such as Sergipe and Amazonas illustrate this contrast. Sergipe is the smallest state in Brazil (21,926 km^2), while Amazonas is the largest (1,559,168 km^2). About 40% (24 out of 62) of Amazonas' municipalities are larger than the entire state of Sergipe. There are also big differences in population density: Sergipe has 40 times more inhabitants per square kilometer than Amazonas (101 vs. 2.5). The higher proportion of women traveling for childbirth in Sergipe may reflect the concentration of maternity services in certain areas, which may cause women to travel to other municipalities for delivery even though the distance may not be very large. The fact that women in the North travel less frequently may be due to a higher proportion of home births (11.7%) compared with the national average (4.1%).[31] Amazonas (17.4%) and Pará (14.8%) have the highest rates of home births in the country.[31] Moreover, it may reflect the challenges posed by long distances and difficult terrain, making travel to distant health facilities impractical for many. Even if women do not cross municipal boundaries, the travel journey to a hospital within their community can still be quite long. These differences highlight the extent to which geographical and demographic factors influence access to healthcare and maternal mobility patterns in Brazil. This suggests that public health planning needs to be tailored to the unique characteristics of each region to improve equity in maternal access.

Additionally, a nationwide study has shown inequalities in public maternity hospital infrastructure and staffing, with the North and Northeast having a lower proportion of hospitals with intensive care units (ICU) (20.8%) than the South, Southeast, and Midwest regions (56.3%).[27] A previous study of 13,044 women showed that obstetric care in the SUS is inadequate in the Legal Amazon and Northeast regions. Traveling for health service utilization in the Northeast (17.9%) was three times higher than in the Legal Amazon (5.7%).[32] There is a need to investigate why the greater number of maternal beds in the Northeast[10] is not associated with a lower proportion of pregnant women traveling to use these services. A recent study conducted in rural Pernambuco found that 66.4% of low-risk pregnant women gave birth in municipalities within 30 km of their municipalities of residence, while 49.1% of high-risk pregnant women gave birth in municipalities more than 120 km away. Most difficulties are related to the availability of high-risk services and obstetric emergencies and the lack of material and human resources.[19]

Possible solutions to the geographic accessibility problem include increasing the number of health facilities and improving physical access to skilled birth attendance services, particularly in the North and Northeast regions. Implementing mobility and incentive policies while encouraging health workers to serve in remote areas could alleviate the problem. Not only would these workers improve access to healthcare for women in these areas, but they would also build trusting relationships with them and improve communication, leading to better health outcomes. Improving the quality of healthcare facilities and hospital infrastructure has the potential to reduce the need for women to travel to higher-quality hospitals for childbirth, while improving patient satisfaction.[33]

In this study, we provide unique insights into changes in travel distances and times of pregnant women in Brazil between two biennia (2010–2011 and 2018–2019), spanning a 10-year period. The study used a comprehensive dataset of reliable national data based on the SUS, providing a universe of more than 6.9 million hospital deliveries to ensure the generalizability of the results across the country. It makes an important contribution to the literature on health access, maternal health, and health equity due to its policy relevance to the Brazilian health system. The results are expected to inform public policies and initiatives aimed at improving women's access to obstetric services by providing evidence and support the evaluation, monitoring, and management of childbirth services.

Some limitations must be considered. Some hospitals that were operating at the beginning of the study period may have closed or lost SUS accreditation. Nevertheless, the observed temporal changes in women's travel flows highlight a broader issue: regardless of the status of a specific hospital, communities still lack access to obstetric services. Using centroids instead of exact residential addresses (due to missing/unavailable data in the SUS Hospital Information System) to calculate accurate travel distance and duration may result in inaccuracies, especially for municipalities with large geographical areas or dispersed populations and may underestimate or overestimate the true travel burden on pregnant women. The fact that some women travel to be closer to family may also lead to an overestimation of the need for long-distance travel purely for medical reasons. As our analysis does not account for referral pathways, total journeys/times may be longer than estimated from our direct travel route estimates. The lack of socioeconomic and health variables in the SUS Hospital Information System database prevents a deeper understanding of how factors such as income, education, or pre-existing medical conditions affect travel distance. Ethnicity may influence travel patterns due to social and structural inequities; however, as data on this characteristic were not consistently or accurately recorded in the SUS Hospital Information System, our ability to assess it was limited. Further studies on travel costs, childbirth pilgrimages, hospital infrastructure, referral pathways, and high-risk pregnancies could build on existing evidence to better understand the requirements needed to improve access to services for pregnant women.

Conclusions

The study highlights the need to review and address regional disparities in obstetric care in Brazil, to reduce the distance and time pregnant women travel, especially in the North and Northeast, where it is more difficult to reach a hospital for delivery. Expanding and redistributing health facilities in underserved areas will ensure more equitable access to maternity services. In addition, improving the infrastructure in existing hospitals will reduce the need to travel long distances to receive better maternal care. Improving transportation networks, including roads and emergency transportation systems, is also critical to addressing the increased travel times associated with adverse birth outcomes. Policymakers should consider providing transportation subsidies or special health transportation services for pregnant women in remote areas. Addressing regional inequalities through targeted, data-driven public policies is a necessary step. Continuous monitoring and evaluation of hospital accessibility will ensure that these measures meet the population's needs. By using tools such as big data and geographic mapping, policymakers can more accurately assess changes in population needs and more effectively allocate resources to improve access to maternal healthcare across Brazil.

Contributors

PCA was responsible for data analysis, results interpretation, visualization and has directly accessed and verified the data reported in the manuscript; LLF was responsible for data extraction, validation, and methodology; JFL was responsible for results interpretation; WST was responsible for the statistical analysis; FZ was responsible for writing-review, and editing; BPF was responsible for project conceptualization and administration, supervision, writing—original draft, review, and editing. She has directly accessed and verified the data reported in the manuscript and has final responsibility for the decision to submit the study for publication. All authors critically revised the manuscript and approved its final version.

Data sharing statement

The data used are public and available from SUS Hospital Information System or can be obtained by contacting the corresponding author.

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Declaration of interests

The authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2024.100976.

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