Inequalities in access to health facilities for birth in Brazil

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Abstract

Despite Brazil's recent social progress, access to health services is still unequal across the country. This article analyzes the traveled distances by pregnant women from their residence municipalities to the actual places of birth in order to document its magnitude and relationship to socioeconomic and birth-related conditions for over a decade in Brazil.

Background

Health access is one of the fundamental pillars for life quality and development according to the World Bank to evaluate multidimensional poverty levels in a given country (World Bank (2017)). Although 91.1% of world population lives up until one hour from a hospital or clinic by motorized transport, only 56.7% are within this time limit by foot and remote regions still remain disconnected (Weiss et al. (2020)). Concerning Brazil, despite many advances in poverty alleviation and inequality reduction over the last decades (World Bank (2022)), public health access is geographically unequal once we assess the distances people need to face to reach these services, as we show further in this article, restricted to birth procedure.

Brazil's Universal Healthcare System (SUS) has equal access as a guiding principle but supply factors differ from one region to another (Travassos et al. (2006); Arruda et al. (2018)). For instance, workforce spatial distribution and socioeconomic inequality impose challenges in guaranteeing a more balanced disposition of facilities and providers (Oliveira et al. (2017)).

Besides that, it is also important to observe the adequacy to risk, looking into the qualitative aspects of care (Travassos and Martins (2004)). Previous research focused on obstetrics has shown how there is space for improvement in this dimension: technology and practices also vary geographically and correlate to mother's characteristics (Menezes et al. (2018)). A better coordination system is argued to play a significant role as displacements have been associated with worse outcomes for newborns (Leal et al. (2020)) and for mothers (Pacagnella et al. (2014)) and a more suitable match between case's needs and facilities should be offered (de Azevedo Bittencourt et al. (2015); Hart (1971)), especially taking into consideration the "delays" involved in healthcare search (Thaddeus and Maine (1994)). Similar associations and causality have been shown in a few developed countries (Neto (2006); Bowman et al. (1988); Kollée et al. (1988)), while difficulties in access are somewhat ubiquitous (Weiss et al. (2020); Gething et al. (2012); Sangho et al. (2020); Van Doorslaer et al. (2006); Grzybowski et al. (2011); Lorch et al. (2013)).

How is access to health facilities at time of birth affected by distances in Brazil? A few articles have presented pieces of evidence on this matter. Looking into data from 2000 to 2015, researchers have identified "hotspots" for neonatal and maternal mortality, mainly in North and Northeast regions, while also pointing out that emergency child and obstetric care can be more than two hours away in several areas depending on the specific equipment (Cristina da Silva et al. (2020)). Similarly, distances for pediatric ICU are more than 120 kilometers away for more than 30 million people (Rocha et al. (2017)). Finally, a paper that uses the same database as we do has assessed a median of 21 kilometers for displacements between municipalities in 2007, with North region surpassing 33 kilometers. Using a multiple regression at the municipal-level, they also found a positive association of kilometers of displacement to birth with infant mortality index (Almeida and Szwarcwald (2012)).

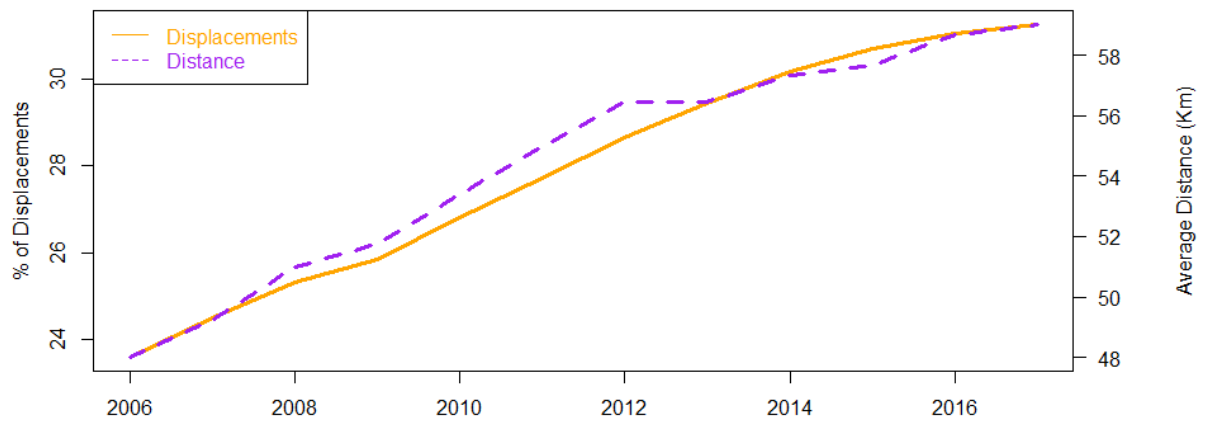
According to data analysis based on Birth in Brazil questionnaires (*"Nascer no Brasil"*), collected in 2011 and 2012, 98.7%of respondents had some pre-natal assistance, 75.8% initiated it before sixteenth gestational week and 73.1% had six or more prenatal appointments during pregnancy. Nonetheless, only 58.7% were directed to a reference maternity unit during appointments and 16.2% had gone to alternative facilities prior to delivery (Viellas et al. (2014)). Hence, although coverage for prenatal care is elevated in Brazil, few women have received proper guidance on where to go, taken together with a growing portion leaving residence municipality, our investigation's results.

Our methodology expands current findings by comprehending a broader scope, in terms of both time and number of observations throughout the country, allowing us to describe displacements trends by pregnant women during twelve years. Our constructed data set

allows us to break the distance and displacement variations by year and state. Moreover, we are able to look into birth-specific characteristics, such as mother socioeconomic background and medical records concerning risk levels, and municipal-level information - for instance GINI index or per capita income - in order to understand potential factors weighting on observed movements and distances.

Figure 1 below illustrates the general movement that has happened in Brazil over the last years. Both the share of pregnant women displacing between municipalities and the average distance they travel to access health facilities for birth were lower in 2006, compared to 2017. The share of displacing women went up from 23% in 2006 to 31% in 2017, while average distance rose from about 48 to 59 kilometers. During this period, these indicators' growth has been steady and almost linear, excepting 2012-2013 when distances were kept constant but resumed escalating right after.

Figure 1: Share of displacements and conditional displaced distance

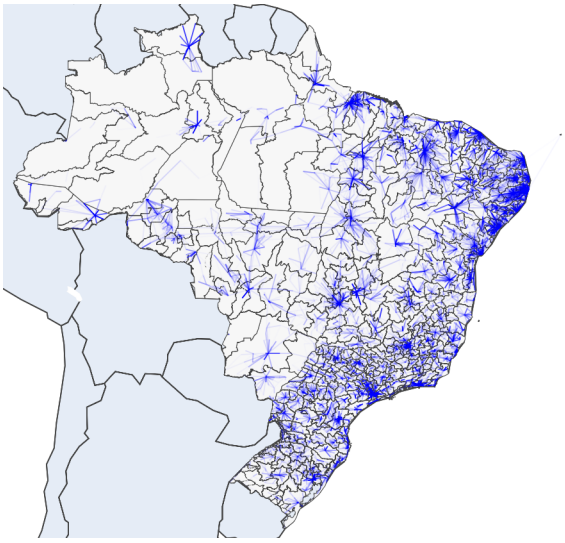


Note: Figure shows share of women who displaced (LHS - in %) and the average distance conditional on displacing by the same group (RHS - in kilometers) at the national level ranging years 2006 to 2017.

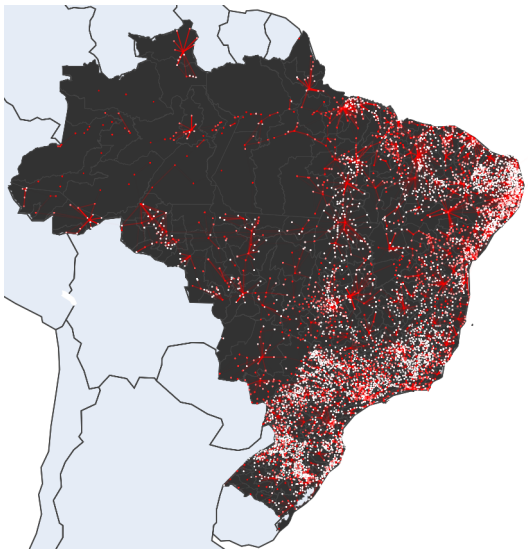
Disparities arise across Brazil, as reflected in Figures 2a and 2b. On the left, blue lines describe flows of pregnant women between municipalities and thickness indicate volume of such displacements. On the right, white dots mark municipalities which most women leave to give birth and color ranges to red signaling fewer displacements. Cities in red are welcoming women from other places. As one can see, South and Southeast regions concentrate flows, but those are short distance as there are many small municipalities, mixing departure (white) and arrival (red) cities.

Figure 2

(a) Intensity of flows



(b) Departure and Arrival



Note: Figure (a) shows connections between municipalities which there was made a displacement made by a pregnant woman. Thick lines indicate more displacements. Figure (b) depicts the degree of share of women displacing: red means most women stay and white means most women leave for the birth.

Methods

In the development of the following analyses, we employed the Brazilian Information System of Live Births (Sistema de Informações sobre Nascidos Vivos - SINASC)[1], to identify pregnant women that displaced to access healthcare services in Brazil and additional information that characterize their socioeconomic background and particularities of their medical cases, such as pregnancy risk level and duration in weeks. All data comes from Data Science Platform applied to Health (Plataforma de Ciência de Dados aplicada à Saúde - PCDaS), which, on its turn, gathers information from DATASUS (Health Ministry database), treats and enriches it using an exclusive ETL methodology, resulting in an annual dataset.

First, births outside mother's residence municipality were identified to assess the share of displacements. Following this, the traveled distances were measured based on routes on public roads. Calculation uses geographic coordinates (latitude and longitude) of each municipality's downtown neighborhood and package *OSM* from *OpenStreetMap* in R software. Thus, we were able to construct the displacement distance in kilometers between every municipality pairing that was a route for a pregnant woman across Brazil from years 2006-2017.

[1]Available for access and download here: https://pcdas.icict.fiocruz.br/conjunto-de-dados/sistema-de-informacao-sobre-nascidos-vivos/

Aggregation by geographic subdivisions and/or birth-level information illustrates tendencies and idiosyncrasies during the twelve years of the sample. Moreover, we complement this with socioeconomic variables extracted from the 2010 Brazilian Census, in order to describe living conditions and traveled distances relationship at the municipal level.

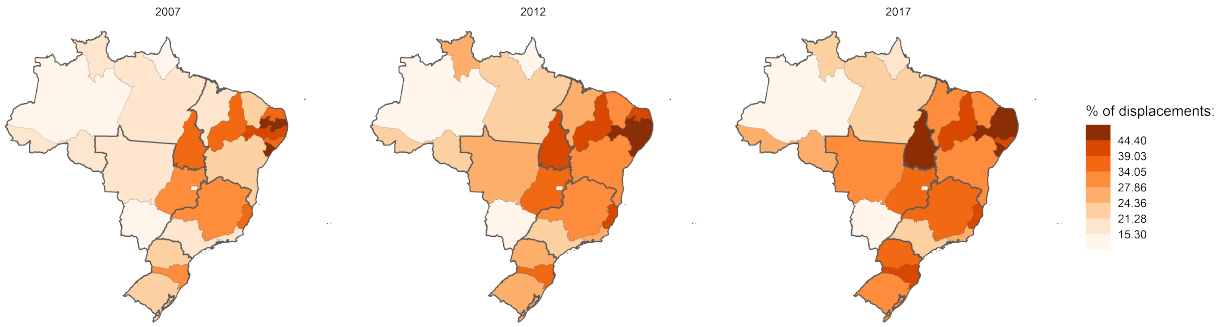
Results

Results are presented in five subsections, covering: i) share of displacements by state, ii) average and GINI index for displaced distances by state, iii) decomposition of trends (displacements versus distances); iv) pregnants' medical characteristics; and v) socioeconomic background.

Share of displacements

Based on the pregnants' recorded displacements, we built maps with the share of births that happen outside of mother's residence municipality, as opposed to the share of those that take place on the same municipality that she lives. Hence, we are able to visualize places whose mothers often leave searching birth services.

Figure 3: Share of Displacements - Overtime by state

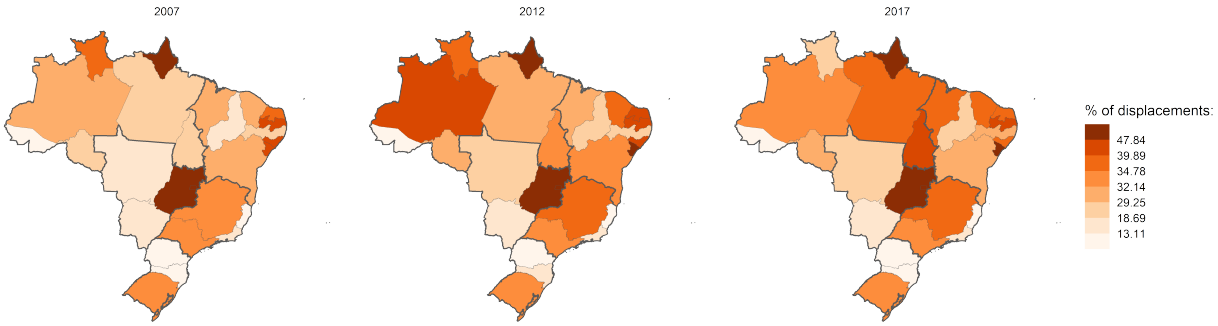


Note: Figure shows share of women who displaced, leaving their residence municipality, by state in 2007 (left), 2012 (center) and 2017 (right).

Figure 3 depicts which states have the highest displacement shares. Across years, we verify that the vast majority of states had an upsurge in such displacements. Five of them have surpassed 44% in 2017, placing in the top bracket: Sergipe, Pernambuco, Paraíba, Rio Grande do Norte e Tocantins. Colors were defined based on the percentiles of displaced

distances nationwide, divided into eight brackets of 12.5%. Thus, the first interval (lightest color) refers to locales below percentile 12.5%; the second embodies those between 12.5% and 25%, and so on.

Figure 4: Share of Displacements leaving Health District - Overtime by state



Note: Figure shows share of women who displaced, leaving their health district, by state in 2007 (left), 2012 (center) and 2017 (right).

As for displacements to another health district, Amapá, Goias, Alagoas and Distrito Federal are the states whose pregnants have incurred in more traveling: over 47% of mothers left their original health district (Figure 4). Ideally, services should be provided within a health district and this scenario might indicate an imperfect coordination of the healthcare system as an integrated network.

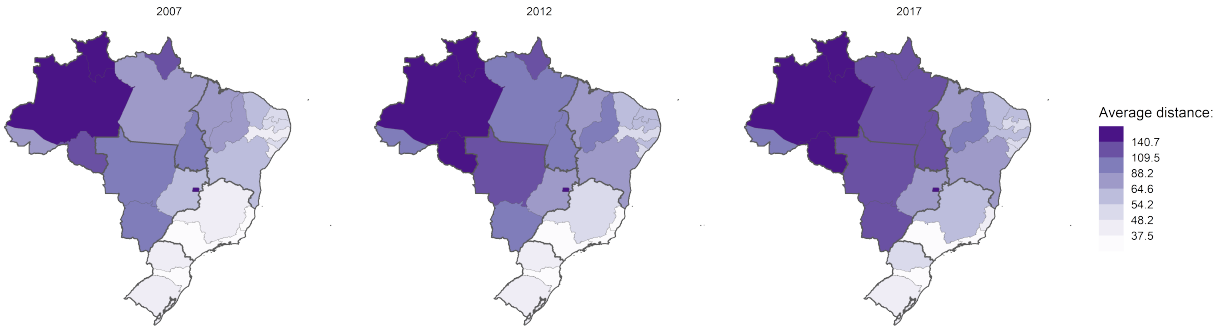
Distances traveled by pregnants

Figure 5 points that North and Central-West regions were the ones where pregnants have traveled the longest distances to give birth (unit is kilometers). Although shares of displacement were low, these women go through over 140 km on average, the top bracket. Median distance is 64.6 Km and lowest bracket has at most 37.5 km. Moreover, figure 5 shows it increased over the depicted time frame, as marked by the darker tones while moving towards 2017.

To better understand geographic distribution and concentration, we assessed the GINI index for displaced distances within state, restricted to displacers, i.e. positive intermunicipal distance[2]. Figure 6 reveals: i) a greater inequality located in regions North and Central-West; and ii) inequality presents a upward trend, rising in most states between 2007 and

[2]The computation used function *ineq* from namesake *R* package

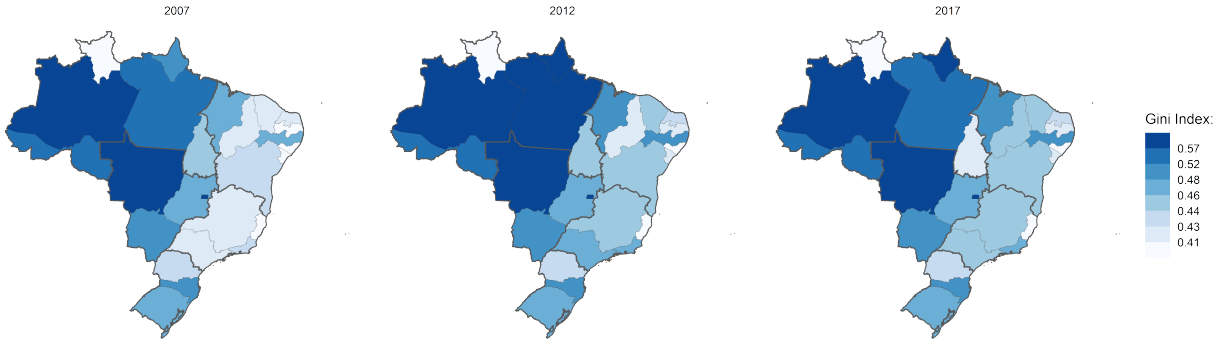
Figure 5: Average (Conditional) Distance - Overtime by state



Note: Figure shows average displacement distance, in kilometers, of women who displaced, by state in 2007 (left), 2012 (center) and 2017 (right).

2017 - Tocantins was the only state to move down a bracket, while about half remaining states were stable and the other half moved up.

Figure 6: GINI of Displacements - Overtime by state



Note: Figure shows GINI index, as a measure of variance and inequality, for displaced distances by state in 2007 (left), 2012 (center) and 2017 (right).

Decomposition of trends (displacements versus distances)

So far, we have documented an increase in displacements and in distances. Since these two phenomenons were identified, we have employed a simple model to decompose and weight properly what drives the current portrait of pregnant women traveling for birth. Three variables were constructed, D, F and C: *"D"* represents the average displaced distance by *all* pregnant women in a given municipality (travelers and non-travelers); *"F"* is the fraction of

those women who traveled; and *"C"* is the average displaced distance, conditional on having traveled (i.e., restricted to positive intermunicipality distances).

By construction, we obtain the following equation relating the three variables: $D = F.C$. Hence, given two years t_0 e t_1, one can break the variation in periods and we analyze the whole timespan, from 2007 to 2017. Variation in *"D"* is approximately given by equation 1 below, in which term $\Delta F.C_t$ represents more people traveling over the years and $F_t.\Delta C$ signals that average distances are increasing with time for travelers. Finally, symbol Δ stands for diference between periods, as in $\Delta F = F_{t1} - F_{t0}$.

$$\Delta D = \Delta F.C + F.\Delta C \tag{1}$$

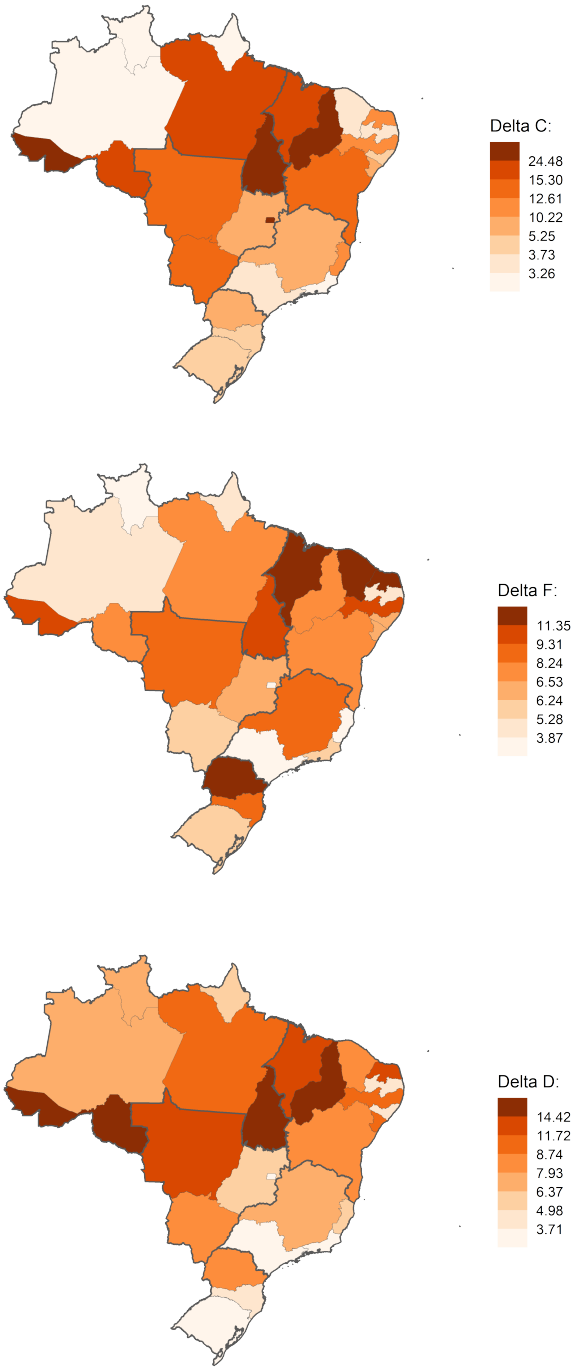
Maps reflecting these variables' variation are shown below. Regarding state-level changes, greater magnitudes are observed in terms of distance, with Tocantins, Acre and Piaui gaining more than 24 kilometers. Other states escalated in fraction of displacers, cases of Maranhão, Ceará, Paraná and Rio Grande do Norte. The combination of those lead to bottom panel in Figure 7, which also illustrates some stability for São Paulo, Pernambuco and Rio de Janeiro, with lowest general variation.

Pregnants' profile and its relationship with displacement

In order to evaluate which characteristics of pregnants are related to the decision/need to displace, we split the sample by whether an attribute was present or not and plotted the share of displacements within each group, generating Figure 8.

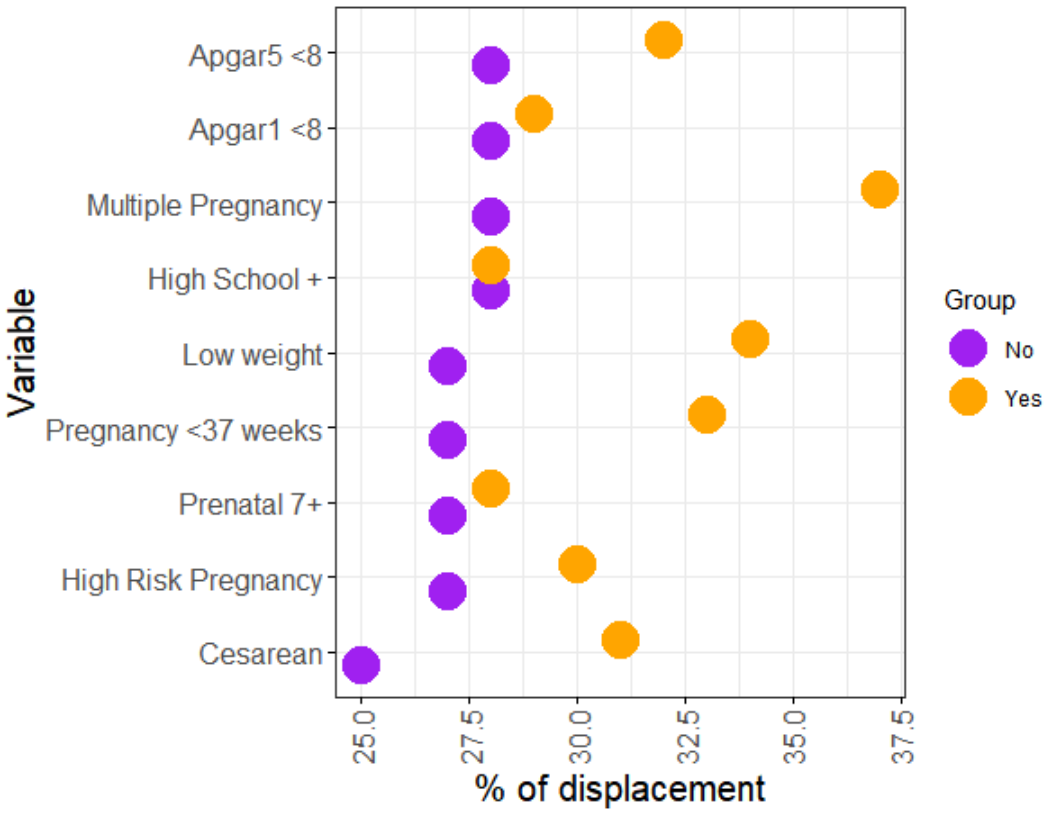
Most distinctive gaps in displacement shares are indicated by risk-related factors. Namely, pregnancies with less than 37 weeks, multiple pregnancy, high-risk pregnancy and low-weight fetus. Other two gaps can also be related to risk: APGAR 5 index, which indicates newborn conditions measured at 5 minutes of life, and the cesarean birth, recommended in cases with complications. APGAR 1 index shows a gap, although smaller than its akin APGAR 5. Having at least high school does not differentiate displacement shares. Attending at least 7 prenatal appointments does not seem to significantly determine displacement as well. During these visits, pregnants should receive guidance on where to attend for the labor procedure. This uniformity, with both groups displacing around 27.5%, corroborates with numbers from Viellas et al. (2014): the high coverage of prenatal does not translate into a better coordination, direction and, consequently, less traveling.

Figure 7: Model Decomposition - Overtime by state



Note: Figure shows components of variation between 2007 and 2017 by state: ΔC - Conditional Distance (top), ΔF - Fraction of Displacements (middle) and ΔD - Unconditional Distance (bottom).

Figure 8: Individual factors and displacement



Note: Figure shows share of displacement (x-axis) by presence of individual factor (y-axis, Yes in yellow and No in purple).

Socioeconomic background and its relationship with distances

In this section, we analyze the relationship between municipal socioeconomic measures and the average distance of pregnants' displacement at the municipal-level. The former measures were extracted from the 2010 Brazilian Census and the latter used SINASC cross-section data from that same year. We have estimated the following model:

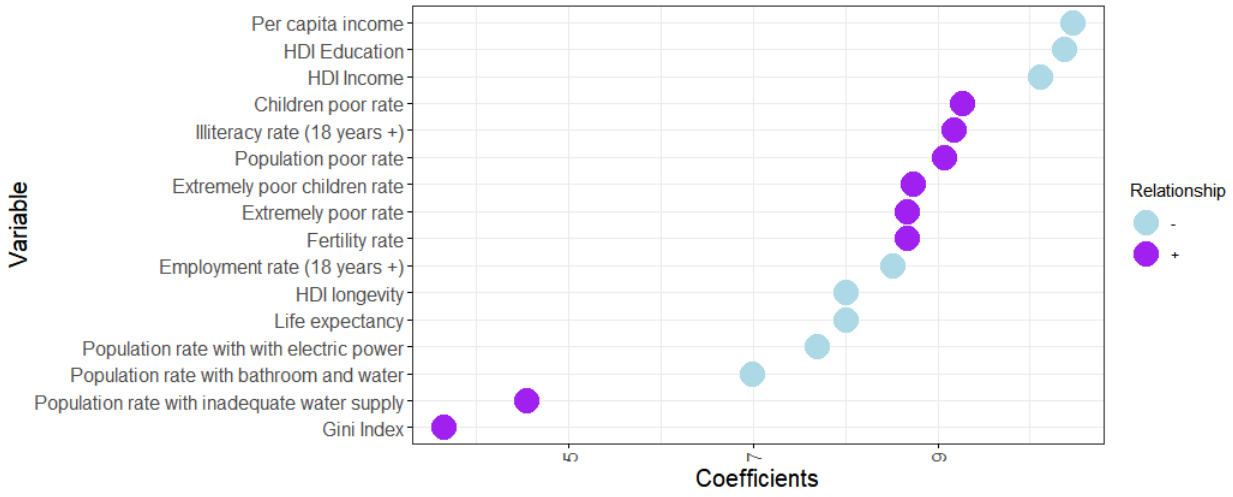
$$D_i = \beta_0 + \beta_1 X_i + \epsilon_i \tag{2}$$

In which: D_i is the average displacement distance made by pregnants of a municipality i, same as in equation 1; X_i is a socioeconomic variable at the municipal-level in i; and ϵ_i is the error term, encompassing all omitted explanatory variables. The model is estimated using one socioeconomic variable at a time, coefficient β_0 is the conditional average distance given the average value of X_i and β_1 is an estimate of correlation between the variable and the

distance. Since the several X_i variables were standardized to z-scores[3], one should interpret β_1 as the additional distance associated with one extra standard deviation of X.

Results are shown in Figure 9. Variables are listed on the y-axis and coefficient β_1 magnitudes are marked on the x-axis. Colors indicate whether coefficient is positive (blue) or negative (purple). Starting on the top-right corner, per capita income, HDI education and HDI income are negatively associated with displacement distance and have the largest magnitudes. This means pregnants living in municipalities placing better on those measures are, on average, traveling less kilometers: one additional standard deviation is associated with a reduction of at least 10 kilometers. On the other hand, child poverty rate, illiteracy rate and population poverty rate are the ones more positively associated, with an expected increase of 9 kilometers by standard deviation. Signals for all variables are coherent and point in the intuitive direction, i.e. distances are expected to be shorter with increasing development levels.

Figure 9: Socioeconomic factors and distance



Note: Figure shows estimated coefficient magnitudes (x-axis) of each socioeconomic factor (list on y-axis) regressed separately at the municipal-level against average displaced distance. Colors indicate the signal of correlation: positive in blue and negative in purple.

[3]Formula: $X_{normalized} = (X - mean(X))/(sd(X))$

Conclusion

As we documented, during studied years, there was an national increase in both the share of displacements leaving residence municipality and the average displaced distance. At the state-level, growth was also recorded, with varying magnitudes across the country. Some displacements were made across health districts, showing the imperfect coordination of the healthcare system, once one was supposed to find care within its limits. Calculations of GINI index reveal distances have become more unequal at the state-level in some parts of Brazil. Finally, for the whole period, median variation of the fraction of displacements was about 6.5 percentage points, while median conditional traveled distance reached a gain by 10 kilometers.

We also show that a potential explanatory factor of displacing is the risk of pregnancy. Several measures related to risk point to a higher share of displacement when compared to the group in which this factor is not present. This holds, for instance, in cases of multiple pregnancy, low-weight fetus and duration below 37 weeks. Cesarean surgery, often made in complicating cases, and (low) APGAR 5 index, assessed after the birth, correlate with risk as well.

Since risk is equally distributed in the territory, the location of services and facilities must be planned to provide adequate care throughout the country. Our description shows a deterioration of conditions for displacement, which likely imposes more challenges to cases already needing special treatment. Another important consideration includes the socioeconomic background of municipalities, once the ones with worse living conditions are associated with longer traveling distances by pregnants. Hence, correcting this matter should reduce inequity by improving life quality of vulnerable populations.

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