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Perinatal health outcomes of international migrant women in Brazil: A nationwide data linkage study of the CIDACS birth cohort (2011–2018)

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A B S T R A C T

Background: We investigated perinatal outcomes among live births from international migrant and local-born mothers in a cohort of low-income individuals in Brazil.
Methods: We linked nationwide birth registries to mortality records and socioeconomic data from the CIDACS Birth Cohort and studied singleton live births of women aged 10–49 years from 1st January 2011 to 31st December 2018. We used logistic regressions to investigate differences in antenatal care, adverse pregnancy outcomes, and neonatal (i.e., ≤28 days) mortality among international migrants compared to non-migrants in Brazil; and explored the interaction between migration, race/ethnicity and living in international border municipalities.
Results: We studied 10,279,011 live births, of which 9469 (0.1 %) were born to international migrants. Migrant women were more likely than their Brazilian-born counterparts to have a previous foetal loss (ORadj: 1.16, 1.11–1.22), a delayed start of antenatal care (i.e., beyond 1st trimester) (1.22, 95%CI:1.16–1.28), a newborn who is large for gestational age (1.29, 1.22–1.36), or a newborn with congenital anomalies (1.37, 1.14–1.65). Conversely, migrant women were less likely to deliver prematurely (0.89, 0.82–0.95) or have a low birth weight infant (0.74, 0.68–0.81). There were no differences in neonatal mortality rates between migrants and non-migrants. Our analyses also showed that, when disparities in perinatal outcomes were present, disparities were mostly concentrated among indigenous mothers in international borders and among live births of Black mothers in non-borders.
Conclusion: Although live births of international migrants generally have lower rates of adverse birth outcomes, our results suggest that indigenous and Black migrant mothers may face disproportionate barriers to accessing antenatal care.

1. Introduction

It is estimated that over 280 million people worldwide are international migrants living outside their country of birth. Of these, approximately one-third reside in Low- and Middle-Income Countries (LMICs) [1]. Like several other Latin American countries, Brazil has benefitted from a sustained period of economic growth and social development, leading to notable improvements in social and health indicators over the last four decades [2,3]. However, as other neighboring countries (e.g., Venezuela) have experienced increased poverty alongside political and economic crises over the past decade, intra-regional migration in Latin America and the Caribbean has intensified [1], with the number of international migrants in the region increasing from 700,000 in 2015 to nearly 1 million in 2019 [1].

In Brazil, the Universal Healthcare System (*Sistema Universal de Saude*, SUS) enables free healthcare access for Brazilians and non-Brazilians; however, entrenched health and social inequalities persist [4,5]. Difficulties in accessing health care may arise for international migrants in Brazil due to language barriers, discrimination, and political and social marginalization. Moreover, as compared to international migrants in High Income Countries (HICs), international migrants in Brazil may be more likely to experience poverty, inadequate nutrition, and hazardous housing and work conditions [6].

Accumulated exposure to social and health inequalities over the life course and specifically during pregnancy has been associated with poorer maternal health and birth outcomes as well as perinatal mortality

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[7,8]. Studies from European and North American contexts investigating antenatal care access and perinatal outcomes among international migrants have frequently reported less timely initiation of antenatal care with variable impacts on perinatal outcomes [9–12]. In Latin America, women are more likely than men to migrate internationally. The causes and consequences for women's migration differs from that of men, and existing gender-related vulnerabilities, especially in relation to sexual and reproductive health, may be exacerbated in the context of migration [13]. However, there is a lack of research on differences in access to antenatal care and perinatal outcomes of international migrants compared to local-born groups in Latin America, in general, and in Brazil, in particular.

To better understand the differences in perinatal outcomes between migrants and non-migrants in Brazil, we used large-scale linked socioeconomic and health records to investigate obstetric history, antenatal care visits, adverse birth outcomes, and neonatal mortality among children born to international migrant mothers and their Brazilian-born counterparts. A better understanding of the differences between migrant and non-migrant outcomes could be used to inform the development of tailored social and health policies that will benefit international migrant women and their infants.

2. Methods

2.1. Study design and data sources

We studied live births in Brazil from the nationwide CIDACS Birth Cohort [14], which links birth registries from the Live Birth Information System (*Sistema de Informação de Nascidos Vivos*, SINASC), death records from the Mortality Information System (*Sistema de Informação em Mortalidade*, SIM) and socioeconomic data from The 100 Million Brazilian Cohort [15].

Live births are registered in SINASC using a standardized birth certificate completed by a health professional (i.e., usually the one assisting in the newborn's delivery). Over 95 % of live births in Brazil are registered with SINASC [16]. From SINASC, we extracted data on the pregnant persons' (i.e., referred hereafter as mothers) and newborn's characteristics, including: previous foetal loss, gestational week that antenatal care started, gestational age at birth, birth weight, APGAR score, and congenital anomalies identified at birth.

Deaths in Brazil are recorded in SIM using a standardized death certificate completed by the physician who certified the individual's death. As of 2011, it was estimated that SIM registered 91 % of infant (i.e., <1-year-old) deaths in Brazil. Although registration rates are improving, regional disparities are still present [17]. From SIM, we extracted the date of death as well as the primary and secondary causes of death.

The 100 Million Brazilian Cohort is an open cohort following up over 130 million individuals who applied for social benefits from 2001 to 2018 in the Brazilian Unified Registry for Social Programmes (*Cadastro Único para Programas Sociais,* CadUnico) [15]. Individuals are eligible to register in CadUnico if the head of family is at least 16 years of age, has a monthly familial income of less than or equal to three minimum wages (approximately USD790 as in 2023) or a monthly per capita income below one minimum wage [18]. Any migrant living in Brazil is eligible to apply as documentation is not required to register. However, individuals are required to have an individual registry number (*Cadastro de Pessoas Físicas*, CPF) to receive social benefits. The cohort baseline comprises the first registration of each individual in CadUnico. From the 100 Million Brazilian Cohort baseline, we extracted data on maternal characteristics, including individual (e.g., age, race/ethnicity, years of schooling, and place of birth (outside or inside Brazil)) and household covariates (e.g., household crowding, sanitation and household conditions, urban/rural area, Brazilian region of residence and monthly per capita income). Within the cohort, it is also possible to identify which individuals are beneficiaries of the *Bolsa Familia* conditional cash transfer programme (BFP), which consists of small monthly monetary transfers of up to approximately USD80 to families living in poverty and extreme poverty, with amounts varying depending on the family size and composition [18].

2.2. Linkage strategy and accuracy

To generate the CIDACS Birth Cohort, SINASC live birth records were linked to the baseline of the 100 Million Brazilian Cohort using the name of the mother, maternal age at birth, maternal date of birth and the municipality of residence of the mother at the time of delivery. The linkage strategy [19] was performed using CIDACS-RL [20], a two-step deterministic linkage tool consisting of an exact linkage between both databases on the matching covariates, followed by a matching process using a similarity score based on the same covariates. In the validation process of this linkage, the mean sensitivity and specificity were over 95 % [19]. To link the CIDACS Birth Cohort to SIM we used two steps. The first using an exact matching with a unique identifier present both in SINASC and SIM, followed by the linkage with CIDACS-RL using the name of the newborn, their date of birth, maternal date of birth and the municipality of residence of the mother at the time of delivery. To evaluate the quality of the linkage between SINASC and SIM, a sample of 2000 pairs stratified into those with high (>0.95), intermediate (0.90–0.95) and low (<0.90) linkage scores was manually reviewed and a mean sensitivity and specificity of over 93 % was obtained [19].

2.3. Study participants

We studied mothers aged 10–49 years and their live births occurring between 1st January 2011 to 31st December 2018. We excluded (i) miscarriages/live births without foetal viability (i.e., delivered before 22 gestational weeks or with birth weight <500g), (ii) multiple pregnancies, (iii) live births that occurred before the birth parent was registered in the 100 Million Brazilian Cohort, (iv) live births without a recorded municipality of residence, and (v) live births with missing data for key confounders defined *a priori* as described below. In addition, when analyzing neonatal mortality, we excluded newborns with insufficient follow-up time (i.e., born less <28 days before the end of the study).

2.4. Variables

We investigated pre-pregnancy risk factors and antenatal, perinatal and postnatal outcomes. Specifically, we studied the following variables: (i) occurrence of previous foetal loss (no/yes), (ii) timely/adequate start of antenatal care (no: first antenatal appointment >1st trimester; yes: first antenatal appointment ≤1st trimester), (iii) prematurity (no: ≥37 weeks; yes: <37 weeks), (iv) low birth weight (LBW; no: birth weight ≥2500 g; yes: birth weight <2500 g), (v) small for gestational age (SGA; no: appropriate for gestational age [AGA, between 10th and 90th percentile of weight for gestational age and sex]; yes: <10th percentile of weight for gestational age and sex) and (vi) large for gestational age (LGA; no: AGA; yes: >90th percentile of weight for gestational age and sex), (vii) poor APGAR score (no: APGAR ≥7; yes: APGAR score at 5 min <7), (viii) congenital anomaly at birth (no/yes), and (ix) neonatal mortality (death within the first 28 days of life). We classified newborn size as small, appropriate, or large for gestational age using sex-specific curves for singleton births from the INTERGROWTH-21st Consortium [21].

Our primary exposure was the migration status of the mother (international migrant versus Brazilian-born) defined based on CadUnico records. We defined international migrant mothers as those who were born in a country other than Brazil and Brazilian-born women as those born in Brazil. We extracted information on potential confounders defined *a priori*: mother's age, mother's level of education, mother's race/ethnicity, Brazilian region of residence and newborn's year of birth (Fig. S1).

2.5. Analysis

We used logistic regressions to calculate the Odds Ratios (OR) and their 95 % Confidence Intervals (95%CI) and evaluate the associations between international migration and obstetric history, antenatal care visits, adverse birth outcomes, and neonatal mortality. Compared to the general population registered in the 100 Million Brazilian Cohort, international migrants are older, have more years of education, have differing racial/ethnic composition and are more likely to reside in urban areas of Brazil [22]. Therefore, we decided to show both the crude and the fully adjusted model for key potential confounders. In addition, to attempt to explore the role of institutional racism [23] as a barrier in accessing maternal and child health services in Brazil, we estimated for each outcome the strata specific point estimates for the interaction between (i) migration status, (ii) self-identified race/ethnicity of the mother (i.e., white, Black, Asian ("*Amarela*"), Brown/Mixed ("*Parda*") and indigenous) and (iii) living in border areas and non-border municipalities with other countries, where services might be more prepared to attend migrant communities.

2.6. Sensitivity analysis

As one of the main drivers of neonatal mortality is prematurity and LBW, we have repeated our main analysis including only live births delivered at term to see if potential differences exist in neonatal mortality between live births at term from migrants and Brazilian-born mothers.

The analysis was performed in Stata 17.

2.7. Ethics

The 100 Million Cohort Study and this study were approved by the ethics committees from Instituto Gonçalo Muniz – Oswaldo Cruz Foundation (Num. 1.612.302 in 2016 and 4.534.397 in 2021). The ethics committee of The London School of Hygiene & Tropical Medicine also approved this study (Num. 22771 in 2021). The unidentified dataset was provided exclusively for this study, and further data access requests must be submitted to Cidacs/Fiocruz subject to Oswaldo Cruz Foundation ethical committee approval.

3. Results

A total of 10,279,011 newborns were included in the study, of whom 10,269,542 (99.9 %) were born to Brazilian-born women and 9469 (0.1 %) were born to international migrant women (Fig. 1). Migrant women who gave birth were generally older than Brazilian-born women, with a lower percentage of mothers between 10 and 18 years (6.6 % vs 17.7 %). Most migrant and Brazilian-born women were Brown/Mixed (61.1 % vs 61.2 %) and had 8–11 years of education (61.0 % vs 60.5 %) (Table S1). A plurality of live births for both migrant and Brazilian-born women occurred in the Northeast region (46.9 % vs 41.8 %). Migrants lived in dwellings with better sanitation than their Brazilian-born counterparts (e.g., 81.3 % vs 67.0 % have access to public water networks and 57.7 % vs 41.0 % have access to public sewage networks). A higher proportion of migrants than Brazilian-born women lived in urban areas (80.8 % vs 69.8 %), while a lower proportion of migrants received benefits from the BFP (69.8 % vs 91.5 %).

A higher proportion of migrant women reported a previous foetal loss (21.7 % vs 18.6 %; $OR_{adj} = 1.16$, 95%CI = 1.11–1.22) and started antenatal consultations after the first trimester of pregnancy (25.7 % vs 25.7 %; $OR_{adj} = 1.22$, 95%CI = 1.16–1.28). Live births from migrant women were more likely to be born LGA (19.4 % vs 16.6 %; $OR_{adj} = 1.29$, 95%CI = 1.22–1.36) and with congenital anomalies (1.2 % vs 0.8 %; $OR_{adj} = 1.37$, 95%CI = 1.14–1.65). Conversely, they were less likely to be premature (9.1 % vs 10.6 %; $OR_{adj} = 0.89$, 95%CI = 0.82–0.95), have LBW (5.9 % vs 7.2 %; $OR_{adj} = 0.74$, 95%CI = 0.68–0.81) or be SGA (6.3 % vs 8.0 %; $OR_{adj} = 0.83$, 95%CI = 0.76–0.90). We found no differences between live births of migrant versus Brazilian-born women in the odds of having low APGAR scores (i.e., APGAR score at 5 min < 7) ($OR_{adj} = 1.06$, 95%CI = 0.87–1.28) and of neonatal mortality ($OR_{adj} =$

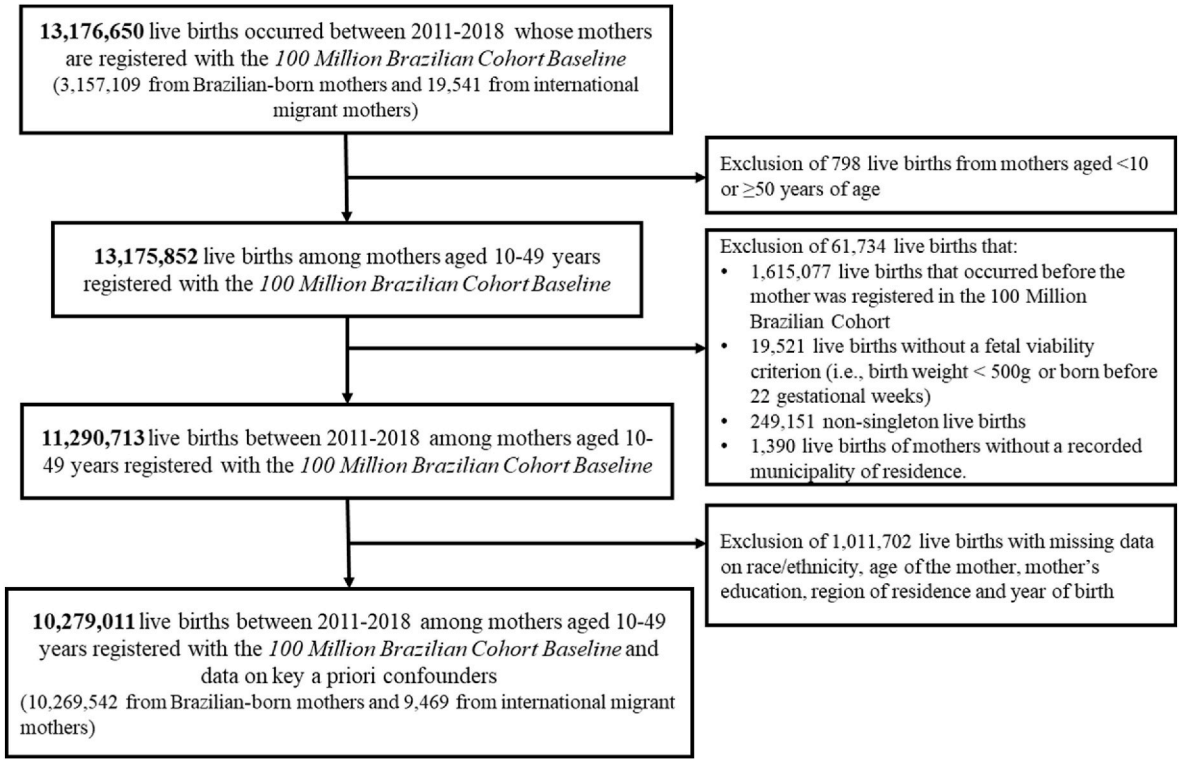

Fig. 1. Live births selected to study perinatal outcomes through the linkage with mortality registries and socioeconomic data.

1.01, 95%CI = 0.79–1.29) (Table 1).

When looking at the intersectional effect of migration and race/ethnicity of the mother on perinatal outcomes (Table 2, Fig. 2A), we found larger differences across race/ethnic strata for migrants as compared to Brazilian-born mothers for the outcomes of previous foetal loss, prematurity, LBW, SGA, LGA and congenital anomalies, but we found no differences between migrant and Brazilian-born women for neonatal mortality risks across race/ethnic strata. When looking only at the intersectional effect of migration and living in border versus non-border areas, point estimates for perinatal outcomes varied across the two different areas (Table S3, Fig. 3B). However, by comparing perinatal outcomes of migrants and Brazilian-born mothers living in international border municipalities compared to non-border municipalities by race/ethnicity (Figure S2, Table S4), we found increased odds of SGA, particularly among live births born to Asian women (OR_{adj} = 2.32, 95% CI = 1.50–3.60), and that higher odds of congenital abnormalities in non-border municipalities was concentrated among live births from migrant Black mothers (OR_{adj} = 2.13, 95%CI = 1.59–2.84). We also observed evidence of increased odds of neonatal deaths among live births from indigenous migrants in border municipalities (OR_{adj} = 11.30, 95%CI = 1.44–88.63).

4. Discussion

In this study, we compared the perinatal outcomes of over 9 thousand live births of international migrant women to over 10 million live births of Brazilian-born women, all of whom were from low-income families that are register with the CadUnico social registry in Brazil. In our study, migrant mothers who delivered a live birth were older, more likely to reside in an urban area, and more likely to have some relative socioeconomic advantages as compared to their Brazilian-born counterparts. We found that, as compared to Brazilian-born women, migrant

Table 1
Distribution, crude and adjusted odds ratio of perinatal outcomes of live births born to international migrants compared to Brazilian-born mothers.

	Live births from international migrant persons (N = 9469)	Live births from Brazilian-born persons (N = 10,269,542)	OR crude (95% CI)	OR_{adj}[c] (95%CI)
	N (%)	N (%)		
Pre-pregnancy risk factors				
Previous foetal loss[a]				
No	7253 (78.3)	7,583,248 (81.4)	1.00	1.00
Yes	2005 (21.7)	1,734,404 (18.6)	1.21 (1.15–1.27)	1.16 (1.11–1.22)
Antenatal care[a]				
Delayed antenatal care				
No (started in first trimester)	6575 (74.3)	6,784,810 (74.3)	1.00	1.00
Yes (>1st trimester)	2269 (25.7)	2,344,595 (25.7)	1.00 (0.95–1.05)	1.22 (1.16–1.28)
Adverse pregnancy outcomes[a]				
Prematurity (<37 weeks)				
No	8519 (90.9)	8,886,675 (89.4)	1.00	1.00
Yes	855 (9.1)	1,058,236 (10.6)	0.84 (0.79–0.90)	0.89 (0.82–0.95)
Low birth weight (<2500g)				
No	8905 (94.1)	9,522,732 (92.8)	1.00	1.00
Yes	558 (5.9)	740851 (7.2)	0.81 (0.74–0.88)	0.74 (0.68–0.81)
Weight for gestational age				
AGA	6671 (74.3)	7,060,503 (75.4)	1.00	1.00
SGA	565 (6.3)	746,250 (8.0)	0.80 (0.74–0.87)	0.83 (0.76–0.90)
LGA	1741 (19.4)	1,554,167 (16.6)	1.19 (1.13–1.25)	1.29 (1.22–1.36)
APGAR at 5 min				
≥7	9253 (98.9)	9,811,474 (98.8)	1.00	1.00
<7	105 (1.1)	114,384 (1.2)	0.97 (0.80–1.18)	1.06 (0.87–1.28)
Congenital abnormalities				
No	9287 (98.8)	9,919,338 (99.2)	1.00	1.00
Yes	114 (1.2)	80,088 (0.8)	1.52 (1.26–1.83)	1.37 (1.14–1.65)
Neonatal mortality[b]				
Neonatal mortality overall				
No	9189 (99.3)	10,115,408 (99.3)	1.00	1.00
Yes	64 (0.7)	72,376 (0.7)	0.97 (0.76–1.25)	1.01 (0.79–1.29)
Neonatal mortality among at term (sensitivity analysis)				
No	8299 (99.7)	8,787,807 (99.7)	1.00	1.00
Yes	22 (0.3)	25,776 (0.3)	0.90 (0.60–1.37)	1.01 (0.66–1.53)

AGA: Adequate for gestational age, SGA: Small for gestational age, LGA: Large for gestational age.

[a] Data is missing for 952,101 (9.3 %) for previous foetal loss, 1,140,762 (11.1 %) for adequate start of antenatal care, 324,726 (3.2 %) for prematurity, 5965 (0.1 %) birth weight, 909,114 (8.8 %) for weight for gestational age, 343,795 (3.3 %) for APGAR at 5 min, 270,184 (2.6 %) for congenital anomalies.

[b] For neonatal deaths, we did not include 81,974 (0.8 %) children that did not have sufficient follow-up time (<28 days).

[c] Odds ratio (OR) obtained using logistic regression adjusted for mother's race/ethnicity, age, education, region of residence and year of birth.

Table 2
Adjusted odds ratio of perinatal outcomes of live births born to international migrants compared to those born to Brazilian-born mothers.

	Live births from international migrant mothers versus Brazilian-born mothers				
	White	**Black**	**Asian**	**Brown/mixed**	**Indigenous**
Pre-pregnancy risk factors					
% Previous foetal loss					
Migrants	576 (19.6)	494 (19.0)	23 (20.4)	870 (25.0)	42 (30.2)
Brazilian-born (ref)	498,401 (17.0)	153,007 (20.7)	7279 (20.3)	1,058,763 (19.2)	16,954 (17.6)
OR_{adj}[a] (95%CI)	1.14 (1.04–1.25)	0.92 (0.84–1.02)	1.01 (0.63–1.61)	1.35 (1.25–1.46)	2.33 (1.61–3.36)
Antenatal care					
% Delayed antenatal care (>1st trimester)					
Migrants	598 (21.6)	628 (24.9)	24 (22)	974 (29.4)	45 (34.4)
Brazilian-born (ref)	576,452 (20.8)	207,396 (29.0)	8846 (24.7)	1,513,906 (27.5)	37,995 (42.9)
OR_{adj}[a] (95%CI)	1.13 (1.03–1.24)	1.12 (1.02–1.23)	1.15 (0.73–1.81)	1.37 (1.27–1.48)	1.26 (0.87–1.82)
Adverse pregnancy outcomes					
% Prematurity (<37 weeks)					
Migrants	286 (9.6)	241 (9.2)	1 (0.9)	319 (9)	8 (5.8)
Brazilian-born (ref)	308,875 (10.1)	87,582 (11.1)	3929 (10.2)	643,591 (10.8)	14,259 (14.8)
OR_{adj}[a] (95%CI)	0.96 (0.85–1.08)	0.90 (0.79–1.03)	0.08 (0.01–0.58)	0.86 (0.77–0.97)	0.42 (0.20–0.85)
% Low birth weight (<2500g)					
Migrants	189 (6.3)	201 (7.6)	2 (1.8)	164 (4.6)	2 (1.4)
Brazilian-born (ref)	225,153 (7.3)	67,256 (8.2)	2802 (7)	438,933 (7.1)	6707 (6.7)
OR_{adj}[a] (95%CI)	0.83 (0.72–0.96)	0.90 (0.78–1.04)	0.21 (0.05–0.84)	0.58 (0.50–0.68)	0.19 (0.05–0.77)
% SGA					
Migrants	166 (5.9)	226 (8.8)	3 (2.7)	168 (5)	2 (1.5)
Brazilian-born (ref)	206,966 (7.3)	67,869 (9.2)	2892 (7.9)	460,152 (8.1)	8371 (9.3)
OR_{adj}[a] (95%CI)	0.87 (0.74–1.01)	1.02 (0.89–1.17)	0.38 (0.12–1.22)	0.67 (0.57–0.79)	0.21 (0.05–0.85)
% LGA					
Migrants	559 (20)	314 (12.2)	30 (27.3)	791 (23.5)	47 (36.2)
Brazilian-born (ref)	453,430 (16)	117,654 (15.9)	6187 (16.8)	958,814 (17)	18,082 (20)
OR_{adj}[a] (95%CI)	1.32 (1.20–1.45)	0.80 (0.71–0.90)	2.02 (0.96–3.09)	1.59 (1.46–1.72)	2.51 (1.75–3.60)
APGAR at 5 min < 7					
Migrants	22 (0.7)	50 (1.9)	1 (0.9)	30 (0.8)	2 (1.5)
Brazilian-born (ref)	31,140 (1)	10,557 (1.3)	417 (1.1)	71,106 (1.2)	1164 (1.4)
OR_{adj}[a] (95%CI)	0.75 (0.49–1.14)	1.71 (1.29–2.27)	0.91 (0.13–6.51)	0.79 (0.55–1.13)	1.30 (0.32–5.24)
Congenital anomaly					
Migrants	28 (0.9)	48 (1.8)	1 (0.9)	36 (1)	1 (0.7)
Brazilian-born (ref)	25,694 (0.8)	6853 (0.9)	304 (0.8)	46,501 (0.8)	736 (0.7)
OR_{adj}[a] (95%CI)	1.07 (0.74–1.55)	1.99 (1.50–2.65)	0.93 (0.13–6.71)	1.18 (0.85–1.65)	0.75 (0.11–5.37)
Neonatal mortality					
Neonatal mortality[b]					
Migrants	18 (0.6)	24 (0.9)	0 (0)	20 (0.6)	2 (1.5)
Brazilian-born (ref)	19,884 (0.6)	6464 (0.8)	265 (0.7)	44,895 (0.7)	868 (0.9)
OR_{adj}[a] (95%CI)	0.95 (0.60–1.52)	1.26 (0.84–1.89)	–	0.82 (0.53–1.27)	2.00 (0.50–8.11)

AGA: Adequate for gestational age, SGA: Small for gestational age, LGA: Large for gestational age.
[a] Adjusted for birth parent's age, education, region of residence and year of birth.
[b] Not enough events among Asian category.

women had higher odds of having had a previous foetal loss, having delayed initiation of antenatal care, and having a newborn with a congenital abnormality, but lower odds of having a premature birth or having a neonate with LBW or SGA.

To date, no studies in Latin America have compared perinatal outcomes of migrant versus non-migrant women; however, access to sexual, reproductive and maternal health services has been studied among Venezuelan migrant women living in Brazilian border municipalities [24,25]. These studies found high rates of inadequate maternity care, with 24.0 % of mothers failing to receive any antenatal care and 68 % receiving no postnatal care in one of the studies [24]; this contrasts strikingly with the Brazilian-born population of whom only 2.9 % do not receive antenatal care [14]. In cities bordering with Venezuela, migrant women reported a lack of knowledge of how to access these services and how to obtain a the card to access SUS (i.e., named "Cartao SUS"), which is usually requested but not mandatory to accessing primary healthcare [26]. Similar studies conducted in border towns of other LMICs have also described specific challenges to accessing sexual and reproductive healthcare, such as distance from health services, lack of services, or cultural and language barriers [27,28]. However, such barriers are a common challenge for migrants access to healthcare services worldwide [29].

In our study, the lower occurrences of LBW, prematurity and SGA among migrants compared to non-migrants were consistent in both crude and adjusted analysis. Similar findings were seen in a systematic review carried out in 2009 looking at perinatal outcomes of migrant women living in HICs compared to the local-born population [30]. However, the study found a high degree of heterogeneity across countries of origin and types of perinatal outcomes [30], which could reflect variation in the type of migration, socioeconomic status and other health conditions. This systematic review further suggested that only studying migration without further exploration of the intricacies of migrants' characteristics and experiences would be insufficient for understanding migrants' health statuses and access to care in the country of arrival.

The higher risk of previous foetal loss among migrant mothers and higher risk of congenital anomalies in their newborns compared to non-migrants is aligned with evidence from longitudinal studies in the UK and Denmark that have suggested an increased prevalence of congenital anomalies among children of migrants [31,32]. However, in these countries, this could be attributed, in part, to consanguinity among migrants [31,32]. In the non-migrant population, a higher risk of LGA infants and congenital anomalies was observed among women with

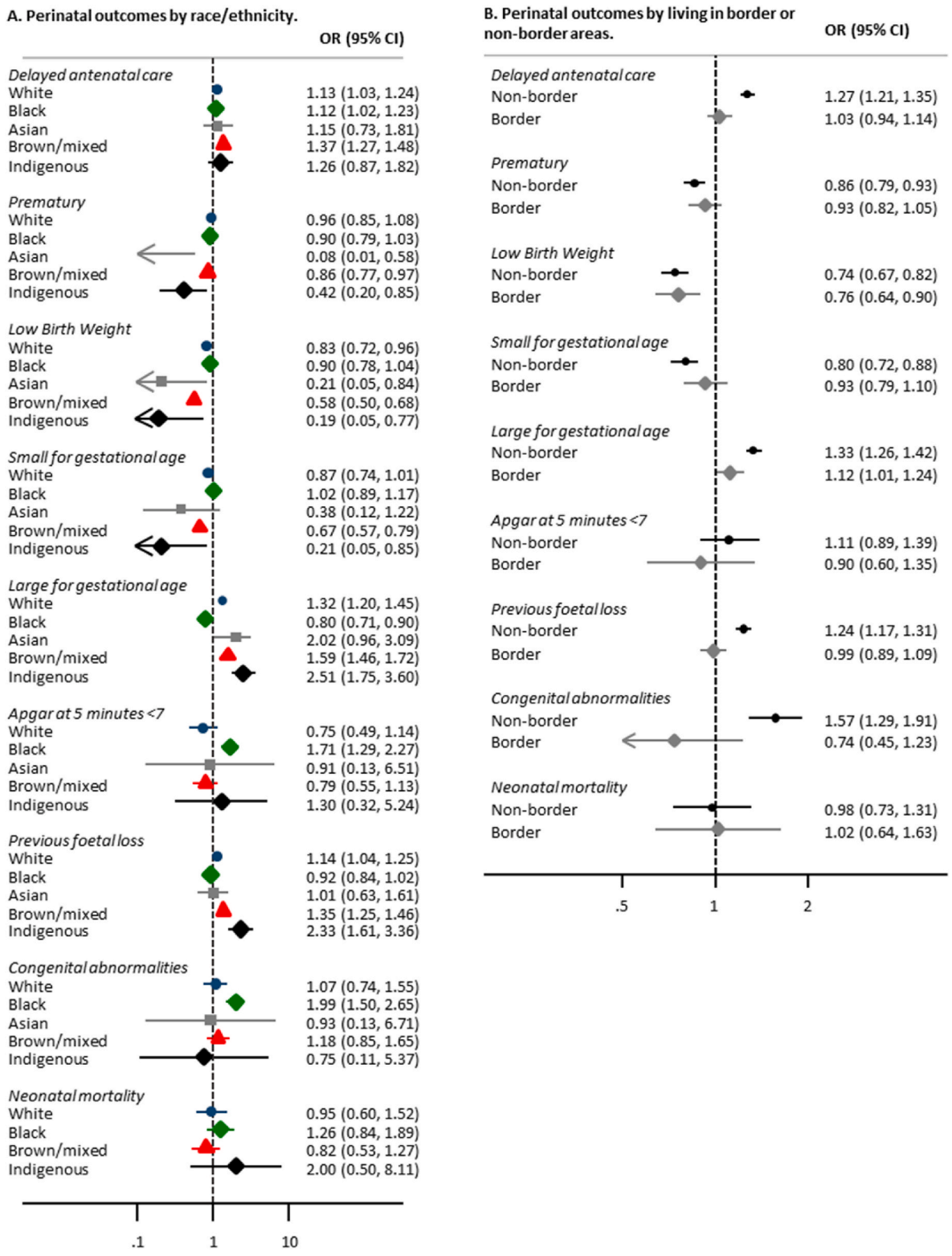

Fig. 2. Adjusted odds ratio (ORs) of perinatal outcomes of live births born to international migrants compared to those born to Brazilian-born mothers. (A) ORs by race/ethnicity adjusted for mother's age, education, region of residence and year of birth; (B) ORs according to place of residence in border or non-border municipalities adjusted for mother's age, education, region of residence, race/ethnicity and year of birth.

pre-gestational or gestational diabetes, advanced maternal age (≥35 years), as well as those who started antenatal care after the first trimester or have an inadequate number of antenatal care visits [33,34]. In our study population, we hypothesize that the elevated risk of congenital anomalies could be due to delayed antenatal care, and inadequate treatment for chronic diseases during pregnancy; however, key clinical risk factors, such as maternal body mass index and presence of gestational diabetes were not available for subsidiary analyses in our datasets.

We also observed that perinatal outcomes varied by self-reported

race/ethnicity and by residence in border/non-border areas, with lower odds of LBW, prematurity and SGA among migrants of indigenous, Brown/Mixed and Asian subgroups. These historically minoritized groups in Brazil have been subject to structural racism, which ultimately led them having lower socioeconomic position than white women in Brazil and would explain the smaller differences of migrants compared to local-born minoritized groups. Similar findings were reported in a Belgian study looking at over 1.3 million live births in which lower risk of LBW and perinatal mortality were identified among migrant women of low socioeconomic status but not among migrants of high socioeconomic status compared to their non-migrants counterparts [35].

When looking at perinatal outcomes of migrants living in international border municipalities compared to non-migrants living in the same area, we found that living in border areas did not seem to influence the relationship between migration and prematurity, LBW or SGA. In addition, the increased risk of the inadequate start of antenatal care, LGA, previous foetal loss and congenital abnormalities were restricted to migrants living in non-border areas. While migrants living in border regions can be a proxy of recent migration, local healthcare services that receive a large migrant population might also be better prepared to assist migrant groups [24]. The stronger effects of migration on congenital anomalies among live births of Black and Brown/mixed migrants living in non-border municipalities may be partially explained by the higher proportion of mothers with a delayed start of antenatal care in this population.

In addition, although we found no differences in the odds of neonatal mortality between live births from migrants compared to non-migrants overall, there was substantially higher neonatal mortality among live births from indigenous mothers living in border areas. To our knowledge, the only other study investigating differences in neonatal mortality between newborn children from migrants versus non-migrant populations in an LMIC was a time-series study conducted in South Africa that found 12 % higher neonatal mortality from children born to Mozambican refugee mothers compared to South African mothers [36]. However, in Brazil, neonatal mortality for specific causes is up to 50-times higher if children are born to indigenous mothers and 3-times higher if they are born to Brown/mixed or Black mothers [5], which highlights the existing health vulnerability and barriers to assistance in this group.

Finally, our study found that migrant mothers access the social protection BFP less frequently than Brazilian-born women. As the BFP targets all families living in poverty (i.e., households with monthly per-capita income of approximately < USD40) or extreme poverty (i.e., households with monthly per-capita income of approximately < USD20) with children under 18 and/or pregnant women in the household, this suggests that migrant mothers are either less likely to be living in extreme poverty compared to non-migrants, or are experiencing barriers in accessing the programme due to, for example, administrative and bureaucratic challenges in obtaining the necessary documentation needed to receive the benefit (i.e., a social security number (CPF)). As there is evidence that programmes like the BFP can reduce child mortality by 17 % in Brazil and have even higher protective effects for children of mothers who self-identify as Black [37], we argue that these families should be supported in navigating bureaucratic processes for obtaining the necessary documentation, and that this should be supported by policies that contribute positively to the integration of migrants into local communities, another factor known to contribute to the reduction in their health disparities.

Our study reinforces that migration and systemic racism may result in significant barriers to indigenous, Brown/mixed and Black mothers' access to high-quality maternity care. These historically minoritized racial, ethnic and cultural groups can be subject to delayed or reduced number of antenatal care appointments, as well as poor quality of consultations (e.g., without measurement of uterine height), and are more likely to be subject to institutional obstetric violence at the time of delivery [38]. Structural racism, leading to economic inequalities, educational disparities, inequitable access to health care, and harmful environmental exposures are especially problematic in the case of migrants, who face additional challenges, such as language barriers and lack of family support, and for whom this could lead to further problems in accessing employment and formalising their immigration status [39].

To our knowledge, this is the first study in an LMIC to use large scale administrative datasets to investigate differences in maternity care and perinatal outcomes among migrant women and their infants compared to local-born women. Our study focused on mothers registered within the CadUnico social benefit registry, which includes Brazil's lowest-income and most socially vulnerable individuals, and provided specific estimates by race/ethnic group and place of residence (border/non-border). While it may limit the generalizability to other international migrant groups in Brazil, such as undocumented migrants and those of higher socioeconomic status, it also provides important insights into the experience of low-income migrants in Brazil. It is also worth noting that as data linkage depends on good quality data, and it is possible that migrants may have disproportionately lower completeness on social or health registries compared to the local-born population, which could have introduced biases. In addition, by excluding multiple births, which are more common in older pregnant people, we might have excluded more live births from migrant mothers and underestimated the association between migration and adverse perinatal outcomes. This dataset also did not have information available on stillbirth, and therefore, further research is warranted to determine whether the protective effect of migration on preterm birth and LBW could be due to higher rates of stillbirth in the migrant population. Finally, the linked datasets lack a number of important variables, including date of arrival in Brazil, country of birth and nationality of the birthing parent, information on the other birth parent, immigration status, and employment conditions (e.g., working hours, living and working in the same place), which would have added further richness to our data. For instance, for migrants, it is impossible to disentangle if the occurrence of previous foetal loss could have happened before or after migration.

Our results suggest that international migrant women in Brazil face barriers to accessing timely antenatal care, which may lead to poor perinatal outcomes, including a higher frequency of congenital anomalies compared to the local-born population. Nevertheless, in this study, migrant women did not have higher rates of prematurity, LBW or neonatal mortality than the local-born population. Factors including maternal race/ethnicity and living in a border municipality at the time of the birth were also found to affect the outcomes by migration status. Policies that bolster the timely initiation of antenatal care and the continuity of care into the postnatal period and beyond, such as active registration into primary health care units and social assistance programmes should be prioritized especially among the most at need populations, including international migrants. Further action and commitment are also needed to design an integrated response to regularize migrants (i.e., provide documentation) and improve access to social and healthcare services, especially for those from minoritized ethnic groups.

5. Data sharing statement

All data supporting this study were obtained from the Center for Data and Knowledge Integration for Health (CIDACS). These were licensed for exclusive use in the present study and, due to the privacy rules of the Brazilian Laws and Ethics Committee, are not openly available. Upon request with adequate justification and approval of an ethics committee, controlled access to data is considered and, if possible, allowed access.

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CRediT authorship contribution statement

Julia M. Pescarini: contributed to study, Conceptualization, contributed to, Data curation, performed the, Formal analysis, contributed to investigation, contributed to, Methodology, contributed to, Visualization, contributed to, Writing – original draft, and all authors contributed to reviewing & editing the final manuscript. **Ila R. Falcao:** contributed to study, Conceptualization, contributed to, Data curation, performed the, Formal analysis, contributed to, Investigation, contributed to, Methodology, contributed to, Writing – original draft, and all authors contributed to reviewing & editing the final manuscript. **Poliana Reboucas:** contributed to study, Conceptualization, contributed to, Investigation, contributed tocontributed to, Writing – original draft, and all authors contributed to reviewing & editing the final manuscript. **Enny S. Paixao:** contributed to study, Conceptualization, contributed to, Data curation, performed the, Formal analysis, contributed to, Investigation, contributed to, Methodology. **Nuria Sanchez-Clemente:** contributed to, Investigation, contributed to, Methodology, contributed to, Writing – original draft, and all authors contributed to reviewing & editing the final manuscript. **Emanuelle F. Goes:** contributed to writing the original draft, and all authors contributed to reviewing & editing the final manuscript. **Ibrahim Abubakar:** contributed to, Investigation. **Laura C. Rodrigues:** contributed to, Funding acquisition, contributed to, Investigation, contributed to, Methodology, administrated the project. **Elizabeth B. Brickley:** contributed to, Funding acquisition, administrated the project, contributed to, Visualization. **Liam Smeeth:** contributed to, Funding acquisition, administrated the project. **Mauricio L. Barreto:** contributed to, Funding acquisition, administrated the project.

Declaration of competing interest

We declare no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tmaid.2023.102672.

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