EXPLORING INEQUALITIES
IN BIRTH OUTCOMES BY MATERNAL CITIZENSHIP:
EVIDENCE FROM LOMBARDY

Chiara Persico, Paolo Berta

Abstract. This study examines disparities in neonatal outcomes between Italian and foreign mothers in Lombardy for the years 2010–2023 using individual-level administrative data from Birth Assistance Certificate (CEDAP). Logistic regression and multilevel models with hospital-level random effects assess the influence of maternal citizenship on outcomes, adjusting for maternal, pregnancy, and delivery characteristics. The initially higher risk of low birth weight among foreign mothers disappears after adjustment, while disparities in preterm birth and Apgar scores persist. However, multilevel models do not reveal any evidence of hospital-based discrimination. Persistent differences may reflect behavioral or genetic factors. Findings highlight the need for broader data and targeted public health and educational efforts to reduce maternal and neonatal health disparities.

1. Introduction

Maternal health is a critical global issue, closely related to economic progress, social stability, and individual and community well-being. Despite notable improvements in healthcare access over recent decades, disparities persist, particularly in neonatal outcomes such as low birth weight (LBW), preterm birth (PTB) and Apgar score (AS). These outcomes not only pose immediate health risks but also have long-term socioeconomic repercussions. In Italy, where universal healthcare exists, these disparities reveal significant socioeconomic and environmental influences, especially among immigrant mothers compared to native Italian mothers.

LBW refers to infants weighing less than 2500 grams at birth (Almond *et al.* (2005)). This condition arises from insufficient intrauterine growth, and it is associated with a mortality risk 20 times higher than that of normal-weight infants. PTB, on the other hand, refers to births occurring before 37 gestational week and is the leading global cause of mortality among children under five years old (Cnattingius *et al.*, 2013). Preterm births may occur spontaneously or because of medical interventions such as induced labour or cesarean delivery. AS is a quick test to assess a newborn's physical condition (at 5-minutes birth), and it evaluates five dimensions (breathing effort, heart rate, muscle tone, reflex response, and skin

colour). An overall score lower than 9 identifies a negative AS (Chong and Karlberg, 2004). These three adverse outcomes will be used to estimate potential inequalities in neonatal health between Italian and foreign mothers in Lombardy over the period 2010–2023.

Recognizing potential risk factors holds value for prevention and targeted actions and social programs could be developed to address the specific needs of at-risk populations (Hidalgo-Lopezosa *et al.*, 2019).

Adverse neonatal outcomes are linked to a significantly heightened risk of death, as well as various future health complications. These include but are not limited to high blood pressure, increased susceptibility to infections, growth restriction, cognitive development issues, cerebral palsy, sensory impairments such as deafness and blindness, as well as respiratory conditions like asthma and lung diseases. LBW is correlated with factors such as lower IQ, behavioral challenges and speech disorders. Furthermore, LBW infants typically demonstrate lower levels of educational attainment, report poorer overall health statuses, and encounter diminished employment prospects and earnings in adulthood compared to their normal-weight counterparts (Almond *et al.*, 2005; Hidalgo-Lopezosa *et al.*, 2019).

An additional consequence concerns socioeconomic status (SES). Maternal socioeconomic status (SES) is a key predictor of birth outcomes, with lower SES and poverty being significantly associated with an increased risk of LBW (Currie and Moretti, 2007). At the same time, the impact of poor neonatal outcomes on later socioeconomic status (SES) is significantly more pronounced for women who give birth in high-poverty areas compared to those in low-poverty areas. Compromised health during childhood could potentially contribute to the intergenerational cycle of poverty. In other words, children born to impoverished adults are more likely to experience health issues, increasing the likelihood that they will remain in poverty when they become parents themselves (Currie and Moretti, 2007).

Extensive research has identified a wide range of factors that influence neonatal outcomes. Key maternal characteristics, such as being younger than 20 or older than 35, body mass index (BMI), have all been shown to play a significant role. Additionally, social determinants including educational attainment, marital status, and access to prenatal care are recognized as important predictors (Almond *et al.*, 2005). Instances of violence and abuse endured by women throughout their lives, including during pregnancy, are acknowledged as potentially modifiable risk factors for adverse pregnancy outcomes (Fried *et al.*, 2008). Then, maternal behaviours such as smoking and substance use, as well as obesity or undernutrition, further increase the risk. Some pregnancy related information and the obstetric history of the mother can be determinants of poor neonatal outcomes: type of birth (C-section), sex of the newborn (male for PTB, female for LBW), and the occurrence of multiple births (twins). The absence of previous children or the presence of congenital defects or

maternal hereditary constraints could also influence the neonatal outcome (Currie, 2020; Hidalgo-Lopezosa *et al.*, 2019; Cnattingius *et al.*, 2013; Currie and Moretti, 2007).

Moreover, geographic and environmental factors significantly impact neonatal outcomes, such as urban living, air pollution, water and soil pollution, and neighborhood SES (Hidalgo-Lopezosa *et al.*, 2019; Coker *et al.*, 2016; Currie and Moretti, 2007).

While the previously identified determinants are broadly applicable to the general maternal population, the migration context, focus of this paper, introduces additional complexities that shape the health trajectories and vulnerabilities of immigrant mothers. Moreover, evidence suggest that migration impacts maternal health through factors related to both origin and destination countries, including SES, healthcare access, job opportunities, housing, and institutional support (Coker *et al.*, 2016; Urquia *et al.*, 2010; Currie and Moretti, 2007). Immigrant mothers often face language barriers, cultural differences, and discrimination (job applications, dining in restaurants, housing rentals, or college admissions), which can limit the quality and accessibility of care. Acculturation can lead to the adoption of unhealthy host-country behaviors, while interethnic unions may both facilitate integration and introduce psychosocial stress. In addition, voluntary migrants tend to be healthier than refugees, and genetic and biological factors also contribute to maternal and neonatal outcomes (Hidalgo-Lopezosa *et al.*, 2019; Giuntella, 2016; Riva and Zanfrini, 2013; Urquia *et al.*, 2010).

2. Background

In Italy, the healthcare system is structured around the National Health Service (NHS), which provides universal coverage and is primarily funded through public taxation. This system ensures that essential healthcare services are accessible to all residents.

The organizational structure of the NHS grants to the Italian Regions considerable autonomy, allowing for heterogeneity in governance models and strategic implementation, conditional on maintaining fiscal balance and ensuring the provision of the essential levels of care.

In this context, our study focuses on the Lombardy Region, which constitutes a distinct case in Italy. Notably, Lombardy is the only region to have formally adopted a 'choice and competition' model (Brenna, 2011), including in the healthcare system both public and private providers. In the last decades Lombardy have been one of the European regions with the highest levels of immigrant presence, providing

valuable insights into the evolving dynamics of immigration in Italy (Mussino *et al.*, 2015).

Understanding immigrants' living conditions is essential for identifying potential disparities with the native population, particularly in areas such as housing, employment, healthcare access, and education. Foreign families in Italy often experience greater economic hardship than Italians, although this varies across communities. While some groups reach comparable income levels, others face marked disadvantages. Migrants are frequently employed in low-skilled jobs despite possessing higher educational qualifications, and few achieve upward occupational mobility, reinforcing socioeconomic inequalities (Barbiano di Belgiojoso, 2017).

3. Data

Data analysis exploits Birth Assistance Certificates (CeDAP) for Lombardy region, covering the years 2010-2023. This administrative data provides a comprehensive overview of all birth events in Lombardy during the specified period.

CeDAP database, filled by healthcare professionals, collects several data. Among these, it is worthy to cite data on parents' socio-demographic information, such as age, nationality, educational level, and employment; pregnancy characteristics such as the mother's obstetric history and labour details are available. In addition, data on previous pregnancies are recorded, for instance the number of previous births, and miscarriages. Information on pregnancy duration, prenatal medical visits, diagnostic tests, and whether conception occurred via assisted reproductive technology was also documented. Finally, information on newborn, such as gender, weight, and Apgar score, and other additional data not considered in our analysis, are collected.

To the aim of this paper, some exclusion criteria have been applied. First, with the aim of restricting a mix of cultural influence, we remove cases where the place of birth and citizenship do not match. Then, we exclude twin births, as multiple births follow distinct distributions that differ from those of LBW and PTB in single births: twins tend to be lighter and, on average, they are typically born earlier than singletons (Almond *et al.*, 2005). In addition, we remove elective C-sections as this group is associated with intrinsic characteristics that could increase the likelihood of poor neonatal outcomes (Silva *et al.*, 2001). Finally, mothers under the age of 15 and over 50, as well as stillbirths, do not meet inclusion criteria due to underlying characteristics that differ from those of the population we aim to study. The application of these exclusion criteria allows us to select for the analysis 858,670 deliveries.

4. Methodology

Since all our outcomes are dichotomous, we exploit logistic regression to assess the coefficients of interest (mother's citizenship) and to adjust the effect of each covariate on the three considered outcomes. We then use a multilevel model to investigate the role of the hospitals in the outcomes' heterogeneity. Finally, an extension to the multilevel model including the random effect of the covariate related to the migrant mothers helps us to capture a potential discrimination effect within the hospitals. Hence, the empirical strategy starts with a logistic regression taking the following form:

$$logit(\Pr(Y_i = 1)) = \alpha + \beta_1 Citizenship_i + \sum_{k=2}^{K} \beta_k X_{ki} \qquad (1)$$

where Y_i equals to 1 when an adverse outcome (LBW, PTB, or AS<9), is observed, and 0 otherwise; β_k is the k-dimensional vector of coefficients related with the k-1 covariates included to adjust the risk of an adverse outcome; β_1 is the coefficient of interest which estimates the difference between Italian and migrant mothers. Several models, including incremental set of covariates, are estimated for each outcome. Model 0 includes exclusively the citizenship variable, whereases Model 1 includes age, level of education, occupation, marital status, father's presence, and local health authority of residence. Model 2 adds to Model 1 the covariates related to the pregnancy: number of previous pregnancies, number of previous C-sections, number of miscarriages, gestational week of first visit, number of ultrasounds, amniocentesis test, ultrasound at 22th week of pregnancy, and the growth defects. Finally Model 3 includes, in addition, sex of newborn, the year of delivery, and the month of delivery. The aim of this strategy is to observe if the initial differences observed in Model 0 in terms of migrant status disappear when the outcomes are adjusted by several groups of relevant covariates.

At this point we exploit a multilevel logistic regression to consider the hierarchical structure of the data and to control the effect of being hospitalized in different hospitals in the regional healthcare system, The multilevel model takes the following form:

$$logit\left(\Pr(Y_{ij} = 1)\right) = \alpha + \beta_1 Citizenship_{ij} + \sum_{k=2}^{K} \beta_k X_{kij} + u_{0j} \qquad (2)$$

which differs from equation (1) by the inclusion of the term u_{oj} capturing unobserved heterogeneity across hospitals in Lombardy and following a Normal distribution with 0 mean and a σ_u^2 variance. In addition, we also consider an extension of equation (2) allowing the effect of the main predictor, Citizenship, to vary by group (hospital) through a random slope (β_{1j}). The multilevel model and

multilevel model with random Citizenship are both estimated in the form of the Model 3 previously described, where all the covariates are included.

5. Descriptive Analysis

The final sample includes 858,670 deliveries occurred in Lombardy between 2010 and 2023, adopting the exclusion criteria previously described. Table 1 reports the cross-distribution of maternal citizenship and place of birth, which was used to define the two study groups: Italian mothers (born in Italy with Italian citizenship) and migrant mothers (foreign-born with non-Italian citizenship). To ensure homogeneity, mixed cases were excluded, resulting in roughly 70% Italian and 28% migrant mothers.

Table 1 – *Maternal Citizenship and Birthplace Distribution.*

Place of Birth	Citizenship	
	Italian	Non-Italian
Italy	716,489 (69.00%)	2,183 (0.21%)
Non-Italy	30,471 (2.93%)	289,229 (27.85%)

Source: Elaboration on Lombardy administrative data (CEDAP)

A more detailed overview of maternal, pregnancy, and delivery characteristics is presented in Table 2. Substantial and systematic differences emerge across most indicators. Migrant mothers are, on average, younger (30.1 vs 33.2 years) and exhibit a greater number of previous pregnancies. They also present a higher frequency of previous C-sections, suggesting a more complex obstetric history.

Significant inequalities are observed in the use of antenatal services. Migrant mothers typically begin prenatal care later (first visit at 9.6 weeks vs 7.8 weeks for Italians) and have smaller number of ultrasound examinations (4.15 vs 5.29 on average), and amniocentesis, reflecting both socioeconomic and cultural factors influencing access to healthcare. Similarly, the share of women attending at least four prenatal visits is markedly lower among migrants (82.9% vs 90.9%).

Socioeconomic differences are even more pronounced. The share of university-educated mothers is more than twice as high among Italians (39.8%) than among migrants (17.9%). Regarding occupation, most Italian mothers are employed (83% vs 31%), while 57% of migrant mothers report themselves as homemakers. Interestingly, the proportion of married mothers is higher among migrants (76.7%) than among Italians (58.7%), suggesting different cultural and family structures.

In addition, trends over time reveal important demographic shifts. ISTAT (2024) data indicate an ongoing process of demographic alignment between foreign and

native mothers in Italy. In Lombardy we observe the same process of reducing fertility and assimilation between Italian and foreign mothers. Total fertility rate gathered by ISTAT reveals that between 2010 and 2023, fertility in Lombardy declined from 1.34 to 1.10 among Italian women and from 2.70 to 1.87 among foreign women. These values reflect a gradual convergence in reproductive behavior between native and migrant mothers.

Table 2 – *Comparison of Maternal, Pregnancy, and Neonatal Characteristics between Italian and Migrant Mothers.*

Variable	Italian	Migrant	
	Mean (SD)	Mean (SD)	p-value
mother's age	33.2352 (4.9325)	30.1335 (5.5803)	***
# previous pregnancies	0.5596 (0.7257)	0.9347 (1.0026)	***
# previous c-sections	0.0435 (0.2195)	0.0849 (0.3263)	***
# miscarriages	0.2408 (0.5869)	0.2531 (0.6064)	***
gestational week of first visit	7.8256 (2.7160)	9.6360 (4.9391)	***
# ultrasound	5.2910 (2.2274)	4.1528 (1.9632)	***
sex newborn (male)	0.5167 (0.0523)	0.5170 (0.0385)	-
mother's educ. level (degree)	0.3975 (0.0489)	0.1785 (0.0239)	***
amniocentesis (yes)	0.0698 (0.0236)	0.0275 (0.0096)	***
ultrasound 22th (yes)	0.9647 (0.0502)	0.9497 (0.0483)	***
growth defects (yes)	0.0184 (0.0124)	0.0211 (0.0084)	***
mother's occupation			***
employed	0.8296 (0.0534)	0.3090 (0.0308)	
stay at home	0.0978 (0.0276)	0.5707 (0.0401)	
mother's marital status (married)	0.5873 (0.0535)	0.7665 (0.0449)	***
# prenatal visits (equal or more than 4)	0.9095 (0.0518)	0.8288 (0.0461)	***
Total Fertility Rate 2010	1.34	2.70	
Total Fertility Rate 2023	1.10	1.87	

Source: Elaboration on Lombardy administrative data (CEDAP). Total fertility rate provided by ISTAT (https://demo.istat.it/app/?i=FE1&l=it) - Note: *** p<0.001, ** p<0.01, * p<0.05.

Finally, Table 3 shows the outcomes' distribution in our data, where LBW occurs in 4.78% of births, slightly lower than PTB rate of 4.90%. AS in the last two columns shows that potential issues at birth affect a small proportion of the sample (3.30%).

Table 3 – *Neonatal outcomes distributions.*

	LBW		PTB		AS	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	41,073	4.78%	41,700	4.90%	28,336	3.30%
No	817,597	95.22%	809,735	95.10%	830,334	96.70%

Source: Elaboration on Lombardy administrative data (CEDAP).

6. Results

Table 4 highlights the four logit models described in the Methodology section, showing that migrant status is associated with a small but statistically significant increase in the likelihood of LBW, however when any additional covariates are included this significance disappears. Regarding PTB, migrant status has a positive and significant effect in all four models, although the size of the coefficient decreases after including additional covariates. Migrant mothers are more likely to experience low AS, highlighting additional disadvantages faced by migrant mothers.

Table 4 – *Estimated Effects of Maternal Citizenship on Neonatal Outcomes across Models with Additional Covariates.*

Outcome	Variable	Model 0	Model 1	Model 2	Model 3
LBW	Intercept	-3.0211***	-4.0501***	-4.4442***	-4.6290***
		(0.0061)	(0.0393)	(0.1036)	(0.1086)
	Migrant Mother	0.0532***	0.0212	-0.0278	-0.0119
		(0.0112)	(0.0141)	(0.0156)	(0.0156)
PTB	Intercept	-3.0322***	-4.3312***	-3.9380***	-4.3292***
		(0.0061)	(0.0387)	(0.0960)	(0.1008)
	Migrant Mother	0.2152***	0.1975***	0.0971***	0.1089***
		(0.0107)	(0.0135)	(0.0143)	(0.0143)
AS	Intercept	-3.4396***	-4.2237***	-4.6278***	-4.6428***
		(0.0074)	(0.0467)	(0.1225)	(0.1272)
	Migrant Mother	0.1942***	0.2057***	0.1999***	0.1949***
		(0.0130)	(0.0164)	(0.0170)	(0.0171)
Covariates:	Mother		√	√	√
Covariates:	Pregnancy			√	√
Covariates:	Delivery				√

Note: Model 0 include only the covariate indicating the foreign status, whereas from Model 1 to Model 3 we include additional covariates adjusting respectively for mothers' characteristics, pregnancy and delivery. - *** p<0.001, ** p<0.01, * p<0.05. Source: Elaboration on Lombardy administrative data

Turning to the results of the multilevel models, we observe in Table 5 that the association between migrant status and neonatal outcomes remains stable when compare with the logistic regression previously described. However, an interesting finding is that the hospital-level effect appears to play a role in shaping these outcomes. As shown in Figure 3, some hospitals exhibit significantly higher risks of LBW, PTB, and low AS, while others appear to offer a protective effect (Berta et al (2020)). Notably, there is no evidence of differential treatment between Italian and migrant mothers at the hospital level. In fact, the estimated random slope model (not reported here) indicates no statistically significant variation in the effect of migrant status across hospitals[1].

Table 5 – *Multilevel models result with random intercept (migrant non b_{ij}).*

	LBW	PTB	AS
Intercept	-3.3962***	-2.2102***	-2.7562***
	(0.0832)	(0.0795)	(0.1023)
Migrant Mother	-0.0252	0.0910***	0.2005***
	(0.0157)	(0.0144)	(0.0172)

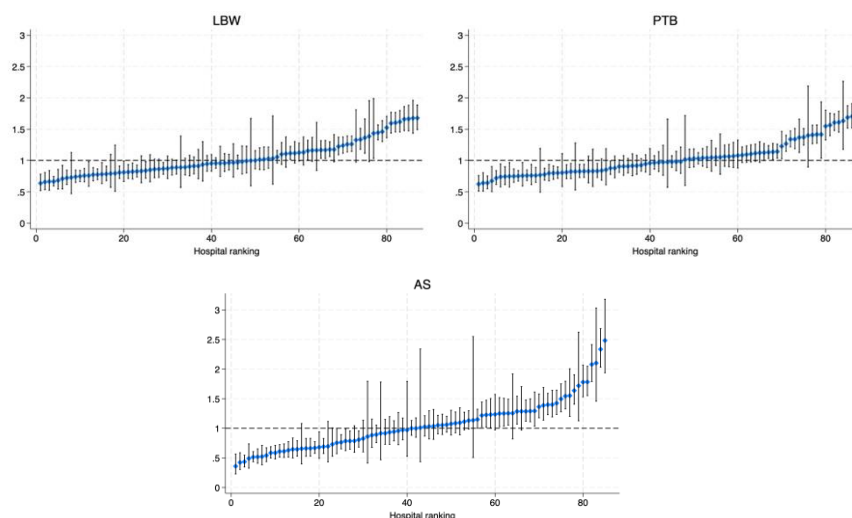*Source: Elaboration on Lombardy administrative data - Note: *** p<0.001,*
** p<0.01, * p<0.05

7. Conclusions

This paper analyses the differences in neonatal outcomes between Italian and migrant mothers, using data from the Lombardy CEDAP between 2010 and 2023. The main results do not evidence any significant differences in the risk of LBW, but show that migrant mothers experience a higher risk of PTB and low AS.

These potential disparities between Italian and migrant mothers can be explained by the substantial differences observed in maternal characteristics and pregnancy pathways. Variations in the use of prenatal care services, time at the first visit, and access to diagnostic tests suggest a different behavior and engagement during pregnancy. These differences highlight that part of the inequality in birth outcomes reflects broader social and cultural determinants rather than differential treatment within the Lombard healthcare system.

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[1] Detailed results of each estimated models (logistic regression, multilevel logistic regression with random intercept, and multilevel logistic regression with random intercept and slope), including the effects of each covariate and the distribution of random effects in the multilevel models are omitted for requested brevity but available upon request.

Figure 3 – *Hospital random effect for LBW, PTB and AS.*

Source: Elaboration on Lombardy administrative data.

In addition, cultural norms and lifestyle could contribute to these gaps, but data availability does not allow us to control for these characteristics. Indeed, smoking, a well-known risk factor in developed countries, mainly affects foetal growth and is linked to LBW but not to the duration of pregnancy, whereas nutritional habits are more related to PTB (Cnattingius *et al.*, 2013). Similarly, because of limitations in the data, we could not control for the level of integration or acculturation in the host (Giuntella, 2016).

In synthesis, our findings highlight that the Lombardy healthcare system appears to be structurally fair, and it can reduce pre-existing inequalities at birth. Still, inequalities in outcomes remain, probably due to cultural differences in prenatal care, genetics, and language or environmental barriers.

To reduce remaining inequalities, clinical care must be combined with broader and more integrated public health policies. It is essential to continue promoting targeted support programs, including cultural mediation, psychological support, personalized education, and a strong local network that can detect vulnerability early. Only through these efforts can formal universalism be transformed into real equity for all newborns.

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Chiara PERSICO, University of Milano Bicocca, c.persico7@campus.unimib.it
Paolo BERTA, University of Milano Bicocca, paolo.berta@unimib.it