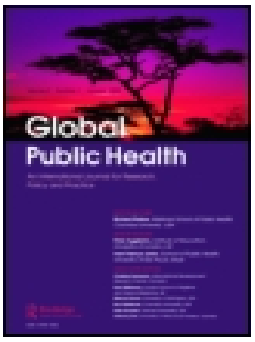

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Explaining ethnic disparities in preterm birth in Argentina and Ecuador

George L. Wehby[a,b], Mariela Pawluk[c], Kwame A. Nyarko[d] and Jorge S. López-Camelo[c,e]

[a]Departments of Health Management and Policy, Economics, and Preventive & Community Dentistry, and Public Policy Center, University of Iowa, Iowa City, IA, USA; [b]National Bureau of Economic Research, Cambridge, MA, USA; [c]Center of Medical Education and Clinical Investigation/Centro de Educación Médica e Investigación Clínica (CEMIC), Buenos Aires, Argentina; [d]Department of Health Management and Policy, University of Iowa, Iowa City, IA, USA; [e]Latin American Collaborative Study of Congenital Anomalies/Estudio Colaborativo Latinoamericano de Malformaciones Congénitas (ECLAMC), Buenos Aires, Argentina

ABSTRACT

Little is understood about racial/ethnic disparities in infant health in South America. We quantified the extent to which the disparity in preterm birth (PTB; <37 gestational weeks) rate between infants of Native only ancestry and those of European only ancestry in Argentina and Ecuador are explained by household socio-economic, demographic, healthcare use, and geographic location indicators. The samples included 5199 infants born between 2000 and 2011 from Argentina and 1579 infants born between 2001 and 2011 from Ecuador. An Oaxaca-Blinder type decomposition model adapted to binary outcomes was estimated to explain the disparity in PTB risk across groups of variables and specific variables. Maternal use of prenatal care services significantly explained the PTB disparity, by nearly 57% and 30% in Argentina and Ecuador, respectively. Household socio-economic status explained an additional 26% of the PTB disparity in Argentina. Differences in maternal use of prenatal care may partly explain ethnic disparities in PTB in Argentina and Ecuador. Improving access to prenatal care may reduce ethnic disparities in PTB risk in these countries.

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Child health; preterm birth; racial disparities; ethnic disparities; health inequalities

Introduction

Socio-economic disparities in infant health outcomes have been reported in various contexts in several South American countries including Argentina, Brazil, Colombia, Ecuador, Chile, and Uruguay (Antunes, Peres, Mello, & Waldman, 2006; Hertel-Fernandez, Giusti, & Sotelo, 2007; Jewell, 2014; Ortiz, Van Camp, Wijaya, Donoso, & Huybregts, 2013; Wehby & McCarthy, 2013; Wehby, Gili, Pawluk, Castilla, & López-Camelo, 2015). Of all relevant socio-economic indicators, race and ethnicity have been the least investigated factors in South American populations, although some evidence points to extensive disparities. Wehby, McCarthy, Castilla, and Murray (2011) reported ethnic disparities in early neurodevelopment in a pooled sample from five South American countries. Similarly, Nyarko,

CONTACT George L. Wehby george-wehby@uiowa.edu
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Lopez-Camelo, Castilla, and Wehby (2013a) found large disparities in low birth weight (LBW; < 2500 grams) and preterm birth (PTB; <37 weeks) rates between infants of European and African ancestry in Brazil. Most recently, Wehby et al. (2015) reported disparities in LBW and PTB by ethnic ancestry in 7 of 8 South American countries with more prominent disparities for PTB. Other studies have also reported racial/ethnic disparities in household factors relevant for infant health such as child health insurance coverage in Argentina, Brazil, and Ecuador (Wehby, Murray, McCarthy, & Castilla, 2011) or in prenatal care use and quality in Brazil (Matijasevich et al., 2009; Victora et al., 2010).

Racial and ethnic disparities in child health are of great concern for policy-makers since they broadly affect large population groups and because early deficits in health do not only reduce well-being during childhood but are also carried forward and expressed in greater health risks and lower socio-economic achievement during adulthood. Furthermore, these disparities are thought to be highly driven by social and economic mechanisms that can be effectively targeted by policies and interventions once identified. Despite extensive research on mechanisms underlying racial/ethnic disparities in health in developed settings such as the USA (e.g. Lhila & Long, 2012), direct research on this question specifically in South American settings is sparse. One study has directly explored contributors to racial disparities in LBW and PTB in Brazil using an Oaxaca-Blinder type decomposition model, and found number of prenatal visits and geographic location to be the most prominent factors in explaining these disparities (Nyarko et al., 2013a). No other work has comprehensively investigated and quantified the pathways that explain racial/ethnic disparities in infant health in South American settings. As mentioned above, the underlying mechanisms for racial/ethnic disparities may vary between countries. For example, Woodhouse, Lopez-Camelo, and Wehby (2014) found that the effects of prenatal care on birth weight vary extensively between several South American countries, suggesting that the extent to which prenatal care explains racial/ethnic disparities is not necessarily generalisable across populations.

In this study, we examined the extent to which various household characteristics including socio-economic, demographic, and healthcare indicators as well as geographic location explain disparities in PTB (<37 gestational weeks) by ethnic ancestry in Argentina and Ecuador, which were recently shown to have large disparities in this outcome (Wehby et al., 2015). In our data-set (described below), these two countries had the largest disparities in PTB between infants of Native only ancestry and those of European only ancestry, and had sufficient samples for addressing this question. PTB is a major adverse birth outcome that is associated with increased infant mortality and risk of neurodevelopmental complications later in childhood (Blencowe et al., 2012; Kent, Wright, & Abdel-Latif, 2012; Morse, Zheng, Tang, & Roth, 2009). Prior work has focused on explaining PTB disparities in Brazil using the same data-set (Nyarko et al., 2013a). No other empirical published work directly investigates and explains ethnic disparities in PTB in Argentina and Ecuador.

Methods

Data and sample

Data were obtained from the Latin American Collaborative Study of Congenital Malformations (ECLAMC), a consortium involving a network of hospitals in South America that is focused on epidemiological surveillance for birth defects (Castilla & Orioli, 2004).

ECLAMC is based on a voluntary collaboration with a group of health professionals (mostly paediatricians) who monitor the occurrence of birth defects among newborns in their hospitals. Affiliated professionals enrol into ECLAMC infants born alive with birth defects as well as a group of infants born in the same hospital without congenital anomalies and matched one-to-one to the infants with birth defects by sex and birth date. ECLAMC professionals collect data on enrolled newborns about infant health and demographics, household demographic and socio-economic indicators, and maternal health conditions and use of prenatal care services through interviews with the mothers before infants are discharged from the hospital after birth and through abstraction of medical records. All infants are recruited following the same enrolment procedures and data are systematically collected using the same questionnaires across all affiliated hospitals. ECLAMC professionals received training in data collection and study procedures. This data-set has been employed in numerous studies of infant health in South America (Nyarko, Lopez-Camelo, Castilla, & Wehby, 2013b; Wehby, Castilla, & Lopez-Camelo, 2010; Wehby, Lopez-Camelo, & Castilla, 2012; Wehby, Nyarko, Lopez-Camelo, & Ohsfeldt, 2014; Woodhouse et al., 2014).

We included infants born in Argentina between 2000 and 2011 and in Ecuador between 2001 and 2011 and enrolled into ECLAMC; 2001 is the first year of ECLAMC data collection in Ecuador. Since birth defects may influence foetal growth and gestational age, our analytical sample only included infants without birth defects. We excluded infants with recorded gestational ages outside of the range 19.5–46.5 weeks to reduce data errors, a standard practice in this literature (Nyarko et al., 2013b). We also only included singleton births, which were nearly 99% of the sample. The main analytical sample with complete data on all study variables included 5119 infants born in 32 hospitals in 19 cities in Argentina and 1579 infants born in 8 hospitals in 7 cities in Ecuador.

Ethnic ancestry

We measured ethnic variation in ancestry following multiple previous studies using ECLAMC data (Nyarko et al., 2013a; Wehby et al., 2010, 2011, 2014; Wehby, McCarthy, et al., 2011; Woodhouse et al., 2014). This measure of ethnic ancestry was innovated by ECLAMC in order to systematically capture ethnic variation across multiple South American countries that are highly ethnically admixed. Mothers were interviewed by ECLAMC professionals about all the ancestries of the child through both maternal and paternal lineages across as many family generations as the mother was able to recall (e.g. child's parents/grandparents/great grandparents/great great-grandparents). Ancestry was systematically coded into unique or mixed ancestry groups.

We focus on the two most frequent groups among unique (i.e. non-mixed) ancestries in our study samples, which were Native only and European only. Native only ancestry meant that the mother only knew about specific child ancestors who were born in Latin America as far back as she could remember. In other words, the mother did not know about any ancestors of the child who were born outside of Latin America. As measured, Native only ancestry does not necessarily mean indigenous ancestry. Indeed for the majority of children, Native only ancestry does not indicate that the child is only of indigenous ancestry but rather that all the child ancestors as far back as the mother could recall (generally up to great great-grandparents) were born in Latin America. Similarly, European only ancestry indicated that the mother recalled specific ancestors of the child who were born in Europe for both parental lineages, and there were no known ancestors from other continents such as Africa or Asia.

It is important to note that many of the children reported to be of Native ancestry only are likely to have had some European ancestry at one point in time. However, in most of those cases, the European ancestors likely migrated to Latin America much earlier than in cases that report specific European ancestors. Therefore, reporting Native only ancestry indicates in most cases having some level of early admixture between indigenous and European ancestries, in contrast to reporting European only ancestry, which in most cases indicates recent European migration [generally up to great (or great–great) grandparent].

We excluded mixed Native and European ancestry because compared to European only ancestry, there was no significant difference in PTB rates in Argentina and only a marginally significant difference in Ecuador (Wehby et al., 2015). Non-European and non-Native ancestries such as African or Asian ancestry were not commonly reported for these two countries (~4% in Argentina and ~8% in Ecuador). Besides being the only two non-mixed ancestries with sufficient sample size for our analysis, there is a large disparity in PTB rate between infants of Native only ancestry and European only ancestry (Wehby et al., 2015), with a much higher rate among infants of Native only ancestry. Only a very small group had missing data on ancestry (~2% in Argentina and ~1% in Ecuador). These observations were excluded from the analysis.

Analytical framework

We modelled PTB risk as a function of conceptually relevant demographic and socio-economic indicators, maternal health, obstetric history, healthcare use, and geographic effects. These factors have been shown to be relevant for birth outcomes in South American populations (Wehby et al., 2010; Woodhouse et al., 2014) and may also vary by ancestry and potentially explain disparities in PTB (Nyarko et al., 2013a). We focused first on broader constructs defined below which we evaluated for their potential in explaining the observed disparities as follows:

$$\text{PTB} = f(ancestry, years, maternalhealthcareuse, maternalhealthandobstetrichistory,$$
$$demographics, householdsocio - economicsstatus, geographiclocation),$$

where *Ancestry* was an indicator for native only ancestry vs. European only ancestry and *Years* included fixed effects for year of birth to account for any time trends in PTB.

Maternal healthcare use: Maternal use of healthcare services during pregnancy was measured by number of prenatal care visits throughout pregnancy and by indicators for receiving immunisations in each trimester. Previous studies have suggested a role for prenatal care in reducing PTB risk (Wehby, Murray, Castilla, Lopez-Camelo, & Ohsfeldt, 2009b). In order to account for potential non-linear effects of prenatal care visits, we included binary (0/1) variables for numbers of prenatal care visits including separate indicators for no prenatal visits, one to two visits, three to five visits, six to eight visits, and nine or more visits (which was used as the reference category). We did not include waiting time before initiating prenatal care as it has been shown in previous studies to be highly confounded in this population, in that mothers who are more likely to deliver preterm were more likely to initiate prenatal care earlier (Wehby et al., 2009b; Wehby, Murray, Castilla, Lopez-Camelo, & Ohsfeldt, 2009c). Immunisations were included as indicators of the intensity/quality of prenatal care.

Maternal health and obstetric history: Maternal health has direct effects on pregnancy complications and illnesses during pregnancy; acute and chronic illness indicators have been shown to be associated with higher PTB risk in ECLAMC birth samples from Argentina and Brazil (Wehby, Murray, Castilla, Lopez-Camelo, & Ohsfeldt, 2009a; Wehby et al., 2009b). Maternal health was measured using an indicator for any acute illnesses during pregnancy such as flu or urinary tract infections and another indicator for any chronic illnesses such as diabetes or hypertension. These were based on maternal self-reports of illnesses during pregnancy. Maternal obstetric history included an indicator for history of conception difficulty and number of previous pregnancies, also self-reported by the mother. Maternal obstetric history captures maternal experience and health knowledge related to pregnancy and foetal health.

Demographics: Household demographic characteristics included indicators for infant sex, maternal age (grouped into six categories to capture non-linear effects: 19 years or younger, 20–24 years, 25–29 years, 30–34 years, 35–39 years, and 40 years or older), and paternal age (grouped into three categories: 24 years or younger, 25–39 years, and 40 years or older). These factors may capture parental preferences and experiences that are relevant for pregnancy progress and foetal health.

Household socio-economic status: Household socio-economic status was measured by indicators for maternal and paternal education and occupational activity coded into multiple categories. Socio-economic status may affect PTB in several ways such as by influencing maternal nutrition, psychosocial status, exposure to environmental hazards, health information, and benefit from prenatal care, and has been shown to be associated with PTB risk in South American countries such as Argentina and Brazil (Wehby et al., 2009a, 2009b). Maternal occupational activity also captures maternal time costs and occupational exposures.

Geographic location: We also measured geographic location by including indicators (fixed effects) for the city where the child was born. Geographic differences in health outcomes, socio-economic conditions, and environmental risks are commonly reported and may play an important role in ethnic disparities due to the residential clustering and segregation by ethnicity. Residential segregation can adversely affect pregnancy and infant health outcomes by reducing access to quality health care, social capital, nutritional resources, and economic opportunities.

PTB disparity decomposition

In order to quantify the contributions of household characteristics and geographic effects to the PTB disparities, we employed a model that extends the Oaxaca-Blinder decomposition model to non-linear models with binary outcomes (Fairlie, 2005; Oaxaca, 1973). The model allows for estimating the extent to which differences in multiple characteristics between two population groups explain their difference in an outcome in a multivariate framework. The explanatory variables can be evaluated in terms of their individual contribution to explaining the outcome disparity or grouped into categories that are each evaluated as one group. This model has been successfully applied in previous studies including work explaining ethnic disparities in child health insurance coverage in several South

American countries (Wehby et al., 2011), and in birth outcomes in Brazil (Nyarko et al., 2013b), and racial disparities in birth weight (Lhila & Long, 2012) and child dental health in the US (Guarnizo-Herreno & Wehby, 2012).

In the case of linear models, a standard decomposition of outcome differences between two population groups essentially replaces the means of explanatory (right-hand-side) variables, one at a time, for one group by the values of the other group, and re-estimates the change in outcome difference between the two groups after each replacement. The outcome disparity between two groups that is explained by a certain variable is simply the change in their outcome difference (at the outcome means) after replacing one group's mean of that specific explanatory variable by the other. While this approach can be applied for a binary outcome by using a linear probability model, it is suboptimal for many reasons such as predicting out of range (0–1) probabilities and ignoring non-linear effects of covariates on probability. Therefore, we focus on the non-linear extension of this model developed specifically for binary outcomes (Fairlie, 2005).

We first estimated Equation (1) listed above using logistic regression. We clustered the standard errors at the hospital of birth to account for any non-independence of observations born within the same hospital. From this logistic regression, we predicted PTB probability for each child. Next within each ancestral group, each child was ranked by their predicted PTB probability in order to match observations between the two groups by their rank of PTB probability. Since the groups differed in size, a subgroup from the larger or 'majority' ancestral group (based on sample size and not rates of the outcome) equal in size to the smaller or 'minority' group was randomly selected for this matching. The children from the 'majority' subgroup, rank-ordered by their probability, were then matched one-to-one with those in the 'minority' group based on their probability rank.

After this matching and for each of the explanatory variables in Equation (1), one variable at a time, the value of the variable was replaced for each observation in the 'minority' group by the value of its matched observation from the 'majority' subgroup. The average of the changes in the probabilities of PTB across observations in the 'minority' group (predicted from Equation (1)) after substituting their values on a certain variable with those from the matched 'majority' subgroup represents the disparity in PTB risk that is explained by the difference in values of that specific variable between the 'minority' and 'majority' groups. This was repeated for each explanatory variable holding the other variables fixed as follows:

$$D_k = \frac{1}{N^M}\sum_{i=1}^{N^M} F\left(a_0 + \sum_{j=1}^{k-1}\beta_j X_{ij}^M + \beta_k X_{ik}^O + \sum_{j=k+1}^{K}\beta_j X_{ij}^O\right) - F\left(a_0 + \sum_{j=1}^{k-1}\beta_j X_{ij}^M + \beta_k X_{ik}^M + \sum_{j=k+1}^{K}\beta_j X_{ij}^O\right). \quad (2)$$

In Equation (2), M represents the minority group and O represents the 'majority' subgroup; N^M is the number of observations in the 'minority' group; j indicates the order of the variables from 1 to K for substituting their values in the 'minority' group by those of 'majority' subgroup; X represents the explanatory variables with X^M representing variables taking their values from the 'minority' group and X^O representing variables taking their values from the 'majority' subgroup; and F is the logit cumulative density function. The disparity in PTB risk (D) explained by the kth variable from a total of K variables (or categories of variables) ordered from 1 to K was estimated by averaging the change in PTB probabilities when replacing the values of k for observations in the 'minority' group by those of their matched observations from the randomly selected 'majority' subgroup. This equation is sequentially estimated for each explanatory variable in the order from 1 to K (shown above for the kth variable). The values of variables ordered 1 through $k-1$ are from the 'minority' group, while the values of variables ordered $k+1$ to K are based on the 'majority' subgroup. The total explained disparity is the sum of the proportions of PTB disparity accounted for by each explanatory variable individually. Alternatively, the total explained disparity may be estimated by simultaneously replacing the values of all explanatory variables in the 'minority' group by those in the matched 'majority' subgroup.

Instead of evaluating individual variables, the model can be estimated for groupings/categories of variables, one group at a time. In that case, the values of all variables in a category are simultaneously replaced in the 'minority' group with those from the 'majority' subgroup. We consider this model to be more powerful for understanding the main constructs that explain these disparities since variables within the same category may be related to each other and therefore not necessarily individually statistically significant in explaining the disparity, but still jointly relevant. We first estimated this model for the five categories of explanatory variables described above: *maternal healthcare use*, *maternal health and obstetric history*, *demographics*, *household socio-economics status*, and *geographic location*. Next, we estimated the model for the variables themselves irrespective of the categories in order to identify the most prominent ones within each category for explaining the disparity.

In order to ensure that the results are not specific to one randomly selected subgroup from the 'majority' sample for matching, we randomly selected 2000 subgroups from the 'majority' sample (each equal in size to the 'minority' group), estimated Equation (2) for each 'majority' subgroup, and averaged the results across the 2000 subgroups. These averaged results approximate those from matching the entire 'majority' sample to the 'minority' sample. Furthermore, with each randomly selected 'majority' subgroup, the ordering of the variable (or category) j was randomly assigned to ensure that the results are not dependent on an arbitrary order. The results therefore approximate the average estimates from all possible variable (or category) orderings and 'majority' subgroups.

Results

Sample description

Table 1 presents descriptive statistics of all model variables by child's ancestry and country. The two countries were similar in their PTB rates by ethnic ancestry. The PTB rate was 10.4% among children of Native ancestry alone and 7.4% among those of European ancestry alone in Argentina, compared to 12.7% and 7.0% in Ecuador.

PTB disparity decomposition

The results from the decomposition model for the five evaluated categories of variables (*maternal healthcare use*, *maternal health and obstetric history*, *demographics*, *household socio-economics status*, and *geographic location*) are in Table 2 (the associations of the explanatory variables with PTB risk from the logistic regression in Equation (1) are in Supplementary Table S1 for Argentina and Supplementary Table S2 for Ecuador). For each country, we show the total difference in PTB rate between child of Native only and European only ancestry, the explained difference based on categories of variables that were significant at least at $p < .05$, and the contribution of each category of variables to explaining the difference, whether significant or not.

Maternal healthcare use significantly ($p < .05$) explained the PTB disparity by about 57% in Argentina and 30% Ecuador (Table 2). In Argentina, *household socio-economic status* explained an additional 26% of the PTB disparity. None of the other categories of variables were significant in explaining this disparity. We describe further the results for each country below.

Argentina

Children of European only ancestry had lower PTB rate than those of Native only ancestry by about 3 percentage-points (Table 1). Of the five evaluated variable categories, only *maternal healthcare use* and *household socio-economic status* significantly explained the PTB rate disparity between these two ethnic groups, by nearly 1.7 percentage-points and 0.8 percentage-points, respectively, of the total 3 percentage-point difference in PTB rate (Table 2). Table 3 presents the contributions of specific variables to the PTB disparity on their own when variables were not grouped in categories. Indicators for no prenatal visits, using one to two visits, and using three to five visits (all relative to using nine or more visits as the reference category) were significant. Among these, the use of three to five visits explained the most – nearly 1 percentage-point of the PTB disparity. This result is driven by both the decline in PTB risk with greater use of prenatal visits (Supplementary Table S1) and the fact that prenatal care use was noticeably lower among mothers of Native only ancestry compared to those of European only ancestry (Table 1). For example, almost 9% of mothers of Native only ancestry had two or fewer prenatal visits throughout the pregnancy compared to 3% of those of European only ancestry. Similarly, nearly 21% of Native only mothers had nine or more visits compared to 36% of mothers of European only ancestry. Immunisations did not significantly explain the PTB disparity; in fact, the results suggest that the disparity would have been larger if the third trimester vaccination rate among Native only mothers were as low as that among European only mothers.

Among the *household socio-economic status* indicators, two variables were individually significant (Table 3): mothers completing secondary school and fathers who have a high occupational status (executive, owner, or boss). Each explained close to 0.5 percentage-points of the PTB disparity. There was a stark difference in socio-economic status by ancestry, with a greater proportion of lower socio-economic status households among Native only mothers (Table 1). For example, almost 50% of Native only mothers did not attend high school, whereas nearly 77% of European only mothers attended high

Table 1. Description of study variables by child's ancestry and country.

	Argentina		Ecuador	
	Native only (N = 3883) % or mean (SD)	European only (N = 1236) % or mean (SD)	Native only (N = 660) % or mean (SD)	European only (N = 919) % or mean (SD)
PTM	10.4	7.4	12.7	7.0
Maternal healthcare				
No prenatal visits	2.3	1.0	1.7	0.3
One to two prenatal visits	6.6	2.3	6.4	1.7
Three to five prenatal visits	30.9	19.8	27.9	17.5
Six to eight prenatal visits	39.4	40.9	54.7	65.8
Nine or more visits	20.7	36.1	9.4	14.6
Vaccination first trimester	14.8	8.1	27.9	18.7
Vaccination second trimester	58.2	58.9	50.5	54.7
Vaccination third trimester	56.1	43.5	28.9	36.0
Maternal health and obstetric history				
Any acute illness				
Yes	38.5	38.9	29.2	36.3
No	61.5	61.1	70.8	63.7
Any chronic illness				
Yes	15.0	14.8	1.8	3.4
No	85.0	85.2	98.2	96.6
Conception difficulty				
Yes	5.9	4.3	3.8	3.0
No	94.1	95.7	96.2	97.0
Number of prior pregnancies	1.8 (2.0)	1.4 (1.8)	1.0 (1.4)	0.8 (1.1)
Demographics				
Female infants	46.1	47.2	40.9	47.3
Male infants	53.9	52.8	59.1	52.7
Maternal age <20	21.5	13.8	18.0	5.2
Maternal age 20–24	32.9	24.4	33.6	24.9
Maternal age 25–29	22.7	27.4	22.6	35.1
Maternal age 30–34	13.5	20.0	16.5	20.6
Maternal age 35–39	6.7	10.7	6.5	11.0
Maternal age ≥40	2.5	3.7	2.7	3.2
Paternal age ≤24	36.5	25.4	36.4	20.2
Paternal age 25–39	54.4	63.2	56.4	69.9
Paternal age ≥40	9.1	11.4	7.3	9.9
Household socio-economic status				
Maternal education[a]				
Primary school incomplete	13.4	6.0	10.8	2.2
Primary school complete	36.1	17.1	31.7	9.2
Secondary school incomplete	30.6	25.7	28.2	18.6
Secondary school complete	16.1	26.1	19.2	32.0
University incomplete	2.7	11.5	5.6	18.9
University complete	1.0	13.6	4.6	19.0
Maternal occupation				
Stay-at-home or unemployed	82.8	65.1	47.3	21.0

(*Continued*)

Table 1. Continued.

	Argentina		Ecuador	
	Native only (N = 3883) % or mean (SD)	European only (N = 1236) % or mean (SD)	Native only (N = 660) % or mean (SD)	European only (N = 919) % or mean (SD)
Unskilled blue collar	8.4	5.3	22.4	10.0
Skilled blue collar	3.4	2.7	10.0	7.1
Independent worker	1.3	4.0	1.4	2.4
Clerk	3.5	11.6	17.0	49.9
Executive, owner, or boss	0.6	11.3	2.0	9.6
Paternal education[a]				
Primary school incomplete	14.0	6.1	7.0	1.2
Primary school complete	40.7	23.7	30.9	8.5
Secondary school incomplete	24.3	23.5	23.3	14.1
Secondary school complete	18.3	26.5	27.7	36.1
University incomplete	2.0	8.7	6.1	19.4
University complete	0.9	11.5	5.0	20.7
Paternal occupation				
Stay-at-home or unemployed	10.7	8.2	6.7	1.6
Unskilled blue collar	35.1	19.5	32.1	8.8
Skilled blue collar	22.9	15.6	21.2	13.8
Independent worker	11.9	17.3	5.2	6.1
Clerk	17.5	22.7	32.1	60.2
Executive, owner, or boss	1.9	16.7	2.7	9.5

Notes: This table shows % of categorical variables and means (standard deviations) for continuous variables. The sample distribution across the city of birth is shown in Supplementary Tables S4 and S5 online.

[a]'Primary school incomplete' refers to parents who did not graduate from primary school; it also includes a small group of illiterate parents as well as literate parents without formal schooling. 'Primary school complete' refers to parents who graduated from primary school but did not have higher education. 'Secondary school incomplete' refers to parents who attended but did not graduate from secondary school. 'Secondary school complete' refers to parents who graduated from secondary school but did not attend university. 'University incomplete' refers to parents who attended but did not graduate from university. 'University complete' refers to parents who graduated from university.

school or had higher education. Similarly, less than 4% of Native only mothers attended or graduated from University, compared to 25% of European only mothers. Such differences were also observed in father's education and in parental occupational status. For example, only 2% of Native only fathers had a high occupational status, compared to 17% of European only fathers. None of the other variables significantly explained the PTB disparity when included on their own.

Ecuador

Children of European only ancestry had lower PTB rate than those of Native only ancestry by nearly 6 percentage-points (Table 1). Similar to Argentina, the differences in *maternal healthcare use* emerged as an important factor, explaining up to 1.7 percentage-points of the total PTB disparity (Table 2). None of the other categories significantly explained this disparity. Table 3 presents the contributions of specific variables to the PTB disparity

Table 2. Decomposition of disparities in PTM rate between children of native only ancestry and those of European only ancestry across categories of variables.

	Argentina	Ecuador
	Native only vs. European only ($N = 5119$)	Native only vs. European only ($N = 1579$)
Difference in PTB rate	−0.0296	−0.0576
Explained difference[a]	−0.0245	−0.0170
% explained	82.8	29.5
% unexplained	17.2	70.5
Variable categories		
Maternal healthcare use	−0.0168*** (0.0040)	−0.0170** (0.0066)
Maternal health and obstetric history	0.0015 (0.0010)	0.0017 (0.0020)
Demographics	−0.0007 (0.0015)	−0.0084 (0.0053)
Household socio-economic status	−0.0077** (0.0037)	−0.0148 (0.0184)
Geographic Location	−0.0011 (0.0035)	−0.0185 (0.0157)

Notes: This table shows the total difference in PTB rate between children of Native only and European only ancestry, the explained difference based on categories of variables that were significant at least at $p < .1$, and the contribution of each category of variables to explaining the difference, whether significant or not (standard errors in parentheses); 'explained' disparities that are of the opposite sign as the total disparity (e.g. maternal health and obstetric history) indicate that the PTB disparity would have been greater if the distribution of the variables in those categories were the same between children of Native only ancestry and those of European only ancestry. The models include year of birth fixed effects.

[a]Explained difference is based on the categories that significantly explained the disparity (at $p < .05$), which includes maternal healthcare use for both countries, and household socio-economic status for Argentina (contributions of insignificant categories not included).

**$p < .05$; ***$p < .01$.

irrespective of variable categorisation. Not receiving prenatal care or only receiving one to two prenatal visits (vs. nine visits) significantly explained the disparity, collectively by nearly 1 percentage-point. Similar to Argentina, prenatal care was associated with lower PTB risk in Ecuador (Supplementary Table S3). Also, prenatal care use was lower among Native only mothers than those of European only ancestry (Table 1). For instance, nearly 8% of European only mothers received two or fewer visits (including no prenatal care), compared to 2% of European only mothers. Receiving nine or more visits was also more frequent among European only mothers (15% vs. 9%). None of the other health-care service use measures significantly explained the disparity.

Three other demographic and socio-economic variables significantly explained the PTB disparity in Ecuador. The higher proportion of very young Native only mothers (18% vs. 5%) explained 1 percentage-point of the disparity. Similarly, the lower proportion of Native only mothers with high occupational status (2% vs. 10%) explained nearly 1 percentage-point. Finally, the lower proportion of Native only fathers with complete secondary school (28% vs. 36%) explained 0.3 percentage-points.

Discussion

We were able to explain an important fraction of the PTB disparity between infants and Native only ancestry and those of European only ancestry in samples from Argentina and Ecuador. Maternal use of prenatal care services emerges as the most important category of variables from all the evaluated household characteristics, explaining up to 57% and 30% of the PTB disparity in Argentina and Ecuador, respectively. In both countries, an increase in prenatal visits was associated with lower PTB risk, consistent with previous studies (e.g. Woodhouse et al., 2014). There were stark socio-economic differences by ancestry, with a

Table 3. Decomposition of the disparity in PTM rate by child's ancestry across variables without grouping variables in categories in decomposition.

	Argentina ($N = 5119$)	Ecuador ($N = 1579$)
No prenatal visits	−0.0051***(0.0014)	−0.0026**(0.001)
One to two prenatal visits	−0.0087***(0.0025)	−0.0066***(0.002)
Three to five prenatal visits	−0.0110***(0.0039)	−0.0051(0.0032)
Six to eight prenatal visits	0.0046*(0.0027)	0.0083**(0.0036)
Nine or more visits	Reference	Reference
Vaccination first trimester	0.0007(0.002)	−0.0071(0.0046)
Vaccination second trimester	−0.0000(0.0003)	−0.0011(0.0012)
Vaccination third trimester	0.0028**(0.0012)	−0.0028(0.0025)
Any acute illness	0.0003(0.0004)	0.0013(0.0017)
Any chronic illness	0.0000(0.0001)	−0.0011**(0.0004)
Conception difficulty	−0.0000(0.0003)	0.0001(0.0006)
Number of prior pregnancies	0.0012(0.0008)	0.0012(0.0022)
Female infants	−0.0002(0.0002)	−0.0008(0.0005)
Maternal age <20	0.0003(0.001)	−0.0112***(0.0041)
Maternal age 20–24	−0.0002(0.0005)	−0.0008(0.0008)
Maternal age 25–29	Reference	Reference
Maternal age 30–34	0.0004(0.0006)	0.0046*(0.0026)
Maternal age 35–39	0.0014(0.0009)	0.0002(0.0006)
Maternal age ≥40	0.0005(0.0006)	−0.0000(0.0003)
Paternal age ≤24	−0.0015(0.0011)	−0.0007(0.0022)
Paternal age 25–39	Reference	Reference
Paternal age ≥40	−0.0000(0.0003)	−0.0000(0.0003)
Maternal education		
Primary school incomplete	Reference	Reference
Primary school complete	0.0028(0.0022)	−0.0005(0.0085)
Secondary school incomplete	0.0000(0.0005)	0.0006(0.0023)
Secondary school complete	−0.0047***(0.0015)	−0.0045(0.0046)
Attended university[a]	−0.0041(0.0051)	−0.0053(0.0098)
Maternal occupation		
Stay-at-home or unemployed	Reference	Reference
Unskilled blue collar	0.0005(0.0004)	0.0055(0.0045)
Skilled blue collar	0.0000(0.0001)	0.0003(0.001)
Independent worker	−0.0003(0.0007)	−0.0003(0.0005)
Clerk	0.0002(0.001)	−0.0009(0.0176)
Executive, owner, or boss	−0.0008(0.0025)	−0.0076**(0.0039)
Paternal education		
Primary school incomplete	Reference	Reference
Primary school complete	0.0015(0.0015)	0.0070(0.0054)
Secondary school incomplete	−0.0001(0.0004)	0.0037(0.0028)
Secondary school complete	−0.0002(0.0014)	−0.0034**(0.0017)
Attended university[a]	−0.0002(0.0031)	−0.0051(0.0053)
Paternal occupation		
Stay-at-home or unemployed	Reference	Reference
Unskilled blue collar	0.0021(0.0014)	0.0043(0.006)
Skilled blue collar	0.0011(0.0008)	0.0023(0.0016)
Independent worker	−0.0017(0.0012)	−0.0001(0.0003)
Clerk	0.0002(0.0007)	−0.0128(0.0098)
Executive, owner, or boss	−0.0041**(0.0018)	0.0020(0.0029)

Notes: This table shows the extent to which each variable contributes to the total difference in PTB rate between children of Native only and European only ancestry, regardless of significance (standard errors in parentheses). Infants of European only ancestry have lower PTB rates than those of Native only ancestry by 0.0296 in Argentina and 0.0576 in Ecuador. Contributions of variables that explain this disparity are negatively signed. Contributions of variables that are of the opposite (positive) sign to this disparity (e.g. obtaining six to eight vs. nine or more visits) indicate that the PTB disparity would have been greater if the distributions of those variables (their proportions or means) were the same between the two ancestry groups. Detailed results for the city of birth are not shown for brevity but are available from the authors upon request. The models include year of birth fixed effects.

[a]Attended university includes both parents who attended university but did not graduate as well as university graduates.

*$p < .1$; **$p < .05$; ***$p < .01$.

greater proportion of Native only children born into lower socio-economic status households than European only children in both countries. In Argentina, parental education and occupational status significantly explained as a group nearly 26% of the PTB disparity. In Ecuador, these variables were not significant as a group, but differences in proportions of high maternal occupations and fathers with complete secondary school education significantly explained the disparity. Native only mothers in Ecuador were much more likely to be very young than European only mothers, which also significantly explained the disparity. The other evaluated variables did not appear to play a key role in explaining the PTB disparity. Interestingly, city of birth did not emerge as a key factor in explaining these disparities, unlike for Brazil where geographic differences in infant health and race/ethnicity distribution were much more prominent (Nyarko et al., 2013a). These findings indicate that mechanisms underlying racial/ethnic disparities in health may differ between South American countries and that study findings are not necessarily generalisable across populations.

Given that prenatal care is a relatively low cost intervention, policies that increase access to prenatal care such as by mandating coverage of prenatal care services in private insurance plans or providing these services in public programs may help in reducing this ethnic disparity in PTB. Increasing prenatal care utilisation may also be associated with an improvement in additional perinatal outcomes such foetal growth and birth weight (Coria-Soto, Bobadilla, & Notzon, 1996; Ickovics et al., 2003; Kogan & Alexander, 1998; Krueger & Scholl, 2000). The World Health Organisation recommends a minimum of five prenatal visits during pregnancy (Villar et al., 2001). However, a sizeable fraction of Native only women in the study samples obtained fewer than five visits including 27% in Argentina and 23% in Ecuador.

These gaps in prenatal care use from the minimum recommended levels illustrate important opportunities for developing maternal health policies to improve access to prenatal care and potentially reduce ethnic disparities in PTB. Inadequate prenatal care use has been shown to be strongly linked to low socio-economic status in South American settings including in Argentina (Wehby et al., 2009b, 2009c). As noted above, Native only mothers are more likely to be of lower socio-economic status than European only mothers. Therefore, comprehensive policies that improve the socio-economic environment of poor women of child bearing age in the study countries are needed. Such efforts may ultimately increase prenatal care utilisation in this group.

Our study is unique in analysing rich infant-level data that were collected and analysed using similar methods across two countries. Measuring race and ethnicity in South American populations is challenging because of the high racial and ethnic admixture and varying perceptions of race and ethnicity between countries. Race and ethnicity are not routinely measured for research or administrative purposes and are vaguely characterised in many South American countries. This does not however mean that there are no perceptions of racial or ethnic variation in the population. The ancestry measure that we employ is innovative and flexible allowing for defining and comparing ethnic groups of sufficient sample sizes. However, a weakness of this measure is dependence on the mother's recall of the child's lineage, which may introduce error and bias that vary with maternal education or socio-economic status, which even though we adjust for, may not be sufficient for completely addressing this issue. The lack of data on the exact recall window and the uncertainty about the child's ancestry and the likely variation of these across mothers suggest measurement error in our ancestry measure. This may result in underestimating the PTB disparities by ethnic ancestry. However, the fact that we observe significant disparities and that we are able to explain an important fraction of these disparities suggests that our results may be even more pronounced without such potential measurement error in ancestry. In other words, this measurement error is unlikely to bias the effects of the explanatory variables upward (i.e. towards explaining more of the disparity) but rather downward (i.e. towards explaining less of the disparity). Another limitation of the ancestry measure is its inability to separate in many cases between indigenous ancestry and early European migrations which could be both reported in the 'Native' group as discussed above; the extent of admixture in this group may vary between the two countries; for example, the Native only group in Ecuador likely includes more indigenous ancestry that the Native only group in Argentina. Clearly, however, cases in the Native only group represent a different ancestry overall from those in the European only group.

A few other limitations are worth discussing. We did not have measures on several conceptually relevant variables such as household income, detailed data on all maternal health problems, aetiology of PTB (medically indicated vs. spontaneous preterm labour), maternal health behaviours (e.g. nutrition and stress) and psychosocial status during pregnancy, and neighbourhood economic and social indicators and were, therefore, unable to evaluate these potential mechanisms. Even though we find no effects of the city of birth on explaining disparities, neighbourhood characteristics within each city may still be relevant. This limitation may have contributed to not explaining a greater fraction of the disparity in Argentina, but it may also be relevant for explaining the differences in use of prenatal services in Ecuador.

A related limitation is that some of the household variables we analyse such as prenatal care use and maternal health and obstetric history are potentially endogenous (i.e. correlated with unobservable confounders) and may have biased effects, which would also bias how much they can explain of the PTB disparities. This is especially important for prenatal care which emerged as the key variable for explaining the PTB disparities. On the one hand, there is the possibility of confounders such as smoking and nutrition that are likely to be correlated with prenatal care and birth outcomes in the same direction. Such confounders may result in over-estimating the effects of prenatal care on PTB and on explaining the ethnic disparity. On the other hand, other unobserved confounders such as pregnancy complications or history of complications in prior pregnancy (e.g. PTB status of prior births) may result in an opposite bias due to adverse selection with women who have greater health risks obtaining more prenatal care. Self-selection into prenatal care based on unobservable confounders has generally been shown in several previous studies (including in studies of South American populations) to result in underestimating the benefits from prenatal care (e.g. Wehby et al., 2009b, 2009c). If so, prenatal care differences could explain even more of the PTB disparity when accounting for the bias from unobservable confounders than in the current model.

These opposite sources of confounding and prior evidence on bias resulting in underestimation of prenatal care effects suggest that it is unlikely that this limitation substantially affects the main implications of our findings. It is impossible however to fully gauge the extent of the bias in this specific context without adequate data on such confounders or exogenous variation in prenatal care to estimate causal effects. ECLAMC began collecting data on smoking during pregnancy, a potential confounder of prenatal care, in recent years. There is however a concern about underreporting of smoking especially for countries such as Ecuador, where 2–3% of the mothers report smoking during pregnancy. In Argentina, nearly 27% of the mothers report smoking during pregnancy.

To examine whether controlling for smoking modified prenatal care effects, we re-estimated the multivariate logistic regression for PTB described above with and without controlling for smoking for births in 2004 through 2011 in Argentina. We found no difference in prenatal care effects on PTB between the two models (Supplementary Table S5). Smoking did not have a significant association with PTB. Also, the extent of the ethnic gap in PTB explained by maternal use of health services (nearly 2 percentage-points) did not change based on whether smoking was controlled for or not.

To examine the extent of confounding from maternal health characteristics, we added to the above sensitivity model specific indicators for the most common illnesses reported in the analysis. We did not include indicators for specific illnesses in the main model because most of these illnesses are too infrequent to be individually analysed in a meaningful way. In this additional check, we added indicators for anaemia, flu, urinary tract infections, hypertension and/or pre-eclampsia (pre-eclampsia too rare to analyse alone), and diabetes. Adding these variables resulted in no changes in the effects of prenatal care (Supplementary Table S5), or in the extent to which maternal use of services explained of the ethnic PTB disparity (nearly 2 percentage-points). Of these indicators, only the indicator for hypertension and/or pre-eclampsia was significantly associated with an increase in PTM risk (OR = 2.3; 95% CI: 1.1–4.8). Furthermore, these indicators and the other measures of maternal health and obstetric history as a group continued not to explain the ethnic PTB disparity. Notwithstanding the potential measurement error in smoking and these health indicators, these sensitivity checks provide assurance for the key results of our main analysis. Like smoking, chronic illnesses were too rare to meaningfully analyse as separate conditions (consistent with the lower rate of any chronic illness compared to Argentina). Controlling for the flu, and urinary tract infections, the two most common acute illnesses, had no impact on the effects of prenatal care or how much use of healthcare services explained the ethnic disparity in PTB.

Another potential caveat is excluding observations from the analytical sample due to missing data. It is unlikely that there are systematic biases in missing data that would bias the conditional relationships between the explanatory variables and PTB or how much they explain of the ethnic disparity in PTB. Imputing missing data introduces the risk of inflating measurement error which may outweigh any benefit gained from a greater sample size. As a sensitivity check, however, we imputed the variables with the highest rate of missing data including PTB, number of prior pregnancies, maternal occupational status, and father's characteristics (age, education, and occupational activity). We also imputed prenatal visits given its importance in explaining the disparities that we observed. For imputation, we employed multivariate models (with different functional forms depending on the distribution of the imputed variables) that included ethnic ancestry, maternal age, maternal education, year and hospital of birth fixed effects as predictors. When imputing PTB and prenatal visits, we also included birth weight as a predictor. These imputations increased the sample size by 1692 observations for Argentina and by 480 observations for Ecuador. We did not find any appreciable difference in the results; the main result continues to be that use of prenatal care is the key factor in explaining the ethnic disparity in PTB in these samples and has consistent effects on PTB.

Our samples were recruited from selective hospitals and may not necessarily be representative of the entire population. Therefore, it is uncertain whether our results are nationally generalisable. Representativeness varies between the two countries because of differences in how many cities are represented in each sample (19 cities in 10 provinces and federal capital district in Argentina, and 7 cities in 5 provinces in Ecuador; list of cities and provinces and total ECLAMC births by city are included in Supplementary Tables S4 and S5). While generalisability is less certain at the country level, it is rather high at the city level. Many ECLAMC hospitals are considered large community hospitals that together cover a relatively large percentage of births in their respective cities. Combined, the total number of births in ECLAMC hospitals in the covered cities represents about 11% and 13.1% of the total births in these cities in Argentina and Ecuador, respectively, based on 2010 census data for Argentina and 2013 census data in Ecuador. Our analytical sample is obviously a small fraction of the total number of births in these hospitals; nonetheless, this indicates that the ECLAMC hospitals from which our sample is selected are major providers of maternity care in their communities. Furthermore, as shown in Table 1, the samples have extensive socio-economic and demographic diversity, which is expected to enhance the generalisability of the results. Also, ancestry was not related to any inclusion/exclusion criteria for enrolling these samples, which make them particularly useful for studying ethnic disparities in the study countries as they are not limited by ancestry biases in selection. Finally, the overwhelming majority of births in these countries occur in healthcare facilities; therefore, there is no real bias from excluding at-home births (Woodhouse et al., 2014). In other words, even though our results may not necessarily be generalisable to the entire birth population in each country, they are likely generalisable to a meaningful proportion of the birth population.

We are aware of no nationally representative child-level data from these countries with data on ethnic ancestry that provide the level of detail on household characteristics that are available in ECLAMC data and that we can employ in this analysis. Therefore, this data-set presents a unique resource for understanding these disparities until adequate nationally representative data-sets become available. The lack of such national data-sets substantially hinders research on social, economic, and healthcare determinants of infant health in the study countries. National data-sets could build on existing birth record registries by expanding the collection of data to cover additional key demographic, socio-economic, and health variables such as the ones utilised in the current study. These data-sets should also include sufficient detail on maternal health (e.g. indicators of specific health problems) and infant health (e.g. aetiology of PTM, foetal growth indicators) to increase the capacity of future maternal and child health research in these countries.

Conclusion

We find that differences in use of prenatal care services explain an important fraction of ethnic/racial disparities in PTB in Argentina and Ecuador. Because prenatal care is a relatively low cost intervention, public policies that increase access to prenatal care may bring important population health benefits by reducing ethnic disparities in PTB these two countries.

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