Published in final edited form as:

Infant Behav Dev. 2017 February ; 46: 100–114. doi:10.1016/j.infbeh.2016.12.001.

Differences in Early Cognitive and Receptive-Expressive Neurodevelopment by Ancestry and Underlying Pathways in Brazil and Argentina

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Abstract

We examine disparities in early child cognitive and receptive-expressive skills by ethnic ancestry among infants aged 3 to 24 months from Brazil and Argentina. We employ unique data on the neurodevelopment of children who were seeking routine well-child care at a set of pediatric clinics in these countries. The sample included children who had normal birth outcomes and no major health complications, allowing us to focus on variation in neurodevelopment among children without major physical health limitations. The physicians attending the pediatric clinics were trained in administering the Bayley Infant Neurodevelopmental Screener, a standardized instrument used to screen an infant's risk of neurodevelopmental problems on various domains of abilities. We evaluate disparities in overall neurodevelopmental scores and risk for neurodevelopmental problems as well as in cognitive functioning and receptive-expressive neurodevelopment. We also examine the extent to which household demographic and socioeconomic characteristics and geographic location explain these disparities. We find large gaps in both cognitive and receptive-expressive neurodevelopment by ancestry. In Brazil, children of African ancestry have lower scores on both cognitive and receptive-expressive domains and on overall neurodevelopment than children of European ancestry. In Argentina, children of Native ancestry have lower scores on these outcomes than children of European ancestry. These gaps however are largely explained by differences in geographic location and household characteristics, highlighting the importance of policies that reduce socioeconomic and geographic disparities in social capital and economic development for eliminating ethnic disparities in infant neurodevelopment.

Keywords

Cognitive skills; receptive-expressive skills; neurodevelopment; racial disparities; ethnic disparities; health inequalities

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1. Introduction

Racial and ethnic disparities in child health have been widely reported in racially admixed Latin American countries. Racial/ethnic gaps in early infant health indicators such as low birth weight or preterm birth have been documented in multiple South American countries including Brazil and Argentina, the two largest countries in South America (Nyarko et al, 2013; Wehby et al, 2015). Disparities in infant mortality and early educational outcomes have also been reported (Wood and Lovell, 1992; Victora et al, 2000; Matijasevich et al, 2008). The consensus around these findings suggests that these gaps are almost entirely explained by differences in demographic and socioeconomic characteristics and geographic location.

Little is known however about racial/ethnic differences in early child neurodevelopment including both cognitive and receptive-expressive skills, which are important outcomes and markers for future health, education, and earnings later in life. Examining racial/ethnic disparities in early child neurodevelopment is important for identifying unwarranted sources of variation in child health and development and related future outcomes. Explaining observed gaps is essential for understanding the pathways underlying these disparities in order to subsequently develop policies and interventions to reduce them.

In this paper, we investigated differences in cognitive and receptive-expressive skills by ethnic ancestry during the first two years of life for two samples of children from Brazil and Argentina and explored potential mechanisms for observed differences. We employed a unique dataset that includes neurodevelopment measures for a sample of healthy children aged 3 to 24 months from Brazil and Argentina. The children had normal birth outcomes (birth weight, gestational age, Apgar scores), no major health complications, allowing us to primarily focus on variation in normal neurodevelopment among children without major physical health limitations. The children were enrolled by attending physicians during routine well-child care visits to pediatric clinics as part of another study of normal neurodevelopment among healthy children in South America, referred to hereafter as the “parent study” (McCarthy et al, 2012). The physicians affiliated with the parent study were trained and calibrated in administering the Bayley Infant Neurodevelopmental Screener, a standardized instrument that screens for infant neurodevelopment problems, achieving an 84.4% inter-rater reliability (McCarthy et al, 2012). The primary outcomes were measures of overall child’s performance on the instrument and on two specific domains including cognitive and receptive-expressive functioning. The physicians also interviewed the mothers about household demographics and socioeconomic characteristics and investments in child development. Child’s race/ethnicity was measured based on the child’s ancestry as reported by the mother in response to a specific question about the ancestries that the child has during her interview with the study physicians.

2. Background

Early-life neurodevelopment affects human capital formation over the course of life. Indicators of early child health and development have been linked to long-run health, cognitive and receptive-expressive development, and economic achievement over the course

of life (Jefferis, Power, and Hertzman, 2002; Victora et al., 2008; Currie, 2009; Figlio et al, 2014). For instance, Helmers and Patnam (2011) report an important effect of child health at age one on cognitive development at age five using data from India. Impaired cognitive and health in adulthood as consequence of low early-life development is manifested in higher medical expenditures, worse health, poor decision-making process, and worse economic outcomes (Case, A., Fertig, A, and Paxson, C. 2005, Fang, Nicholas, and Silverman, 2010; John J. McArdle, Smith, and Willis, 2009; Smith, McArdle, and Willis, 2010).

There are multiple developmental pathways involving both cognitive and receptive-expressive skill formation that link challenged early development with declines in long-term health outcomes and human capital formation. For example, early impairments of memory, communication skills, critical judgment and planning and accumulations of these impairments over time could ultimately result in poorer decision-making ability and lower educational achievement (Fang et al., 2010; McArdle et al., 2009). Interventions to improve early neurodevelopment are especially important due to the complementarity between investments over time and the self-producing effects of child cognitive and receptive-expressive skills; these effects produce a dynamic process of development and skill formation that perpetuate and widen over time (Cunha and Heckman, 2007). There is evidence that interventions targeting cognitive and psychosocial development early in childhood result in improved labor market outcomes during adulthood not only in developed but also in developing settings (Gertler et al, 2014). Therefore, differences in neurodevelopment and formation of cognitive and receptive-expressive skills very early in life including during infancy and toddler years could translate into large differences in human capital and health outcomes later as a result of this process.

Variation in early neurodevelopment between individuals could be driven by multiple factors such as presence of one or both parents (Zhang, H. et al 2014), household environment especially the quality and intensity of parental investments (Wehby et al, 2011a; Helmers, C. and Patnam, M. 2011) and maternal health behaviors during pregnancy (2011b), and quality of physical and socioeconomic environment. However, gaps in child development across population demographic factors such as race/ethnicity are of greater concern and interest for policymakers than general variation between individuals because of their broad effects on large groups of the population and the consensus that they are largely rooted in policy-sensitive social and economic factors of the environments in which children grow, which could ultimately modify household effects on child development.

The literature on racial/ethnic disparities in neurodevelopment very early in life including during infancy is sparse. Wehby et al (2011) study disparities in the first two years of life in a pooled sample across multiple countries in South America and observe important racial/ethnic disparities that are partly explained by differences in household investments. Fryer and Levitt (2013) evaluate racial differences in cognitive development in the US at different stages of childhood. They find no differences in the first year of life but observe differences later between black and white children. A broader literature has examined socioeconomic differences in neurodevelopmental outcomes early in life and later in childhood and reported socioeconomic gaps in various settings including in samples from South America (Paxson and Schady, 2007; Wehby and McCarthy, 2013), US (Todd and Wolpin, 2007), and the UK

(Ermisch, 2008). Since socioeconomic differences by race/ethnicity are commonly reported, this literature suggests that racial/ethnic disparities in early neurodevelopment may be common in racially/ethnically admixed countries such as South American countries.

Our paper makes several important contributions to the literature on disparities in early child development. Little is known about the extent of racial/ethnic disparities in early neurodevelopment, not only in South American countries but also in other racially/ethnically admixed countries. Unlike physical health outcomes such as birth weight that are commonly measured in surveys of child health, neurodevelopment outcomes are much less frequently captured as they require specific instruments typically administered by trained health professionals. Such data have been sparse particularly for children during the first few years of life.

Using unique data including measures of neurodevelopment obtained by trained physicians for a sample of children during the first two years of life, our study quantifies racial/ethnic disparities in neurodevelopment very early in life in two large and racially/ethnically admixed South American countries. South American countries are particularly of interest for studying disparities since they are highly racially/ethnically admixed. We examine both overall neurodevelopment as well as specific neurodevelopment domains including cognitive and receptive-expressive development. Furthermore, we investigate two main mechanisms including household and area-level effects. The findings shed light on the extent to which such disparities occur in neurodevelopment very early in life and underlying pathways, which is informative for other countries and settings with comparable population characteristics.

Our work also has broader implications for understanding the early unwarranted sources of variation in long-term economic outcomes in South American countries. Hanushek and Woessmann (2012) identify educational underachievement, an indicator of human capital, as a key pathway for the lower economic development in Latin American countries compared to the rest of the world. Our work points to social determinants of early cognitive and receptive-expressive skills, which can be considered an early form of human capital. Ethnic differences in early child neurodevelopment may contribute to (possibly larger) differences in educational achievement later in childhood and subsequently in labor market outcomes such as employment and earnings. For example, the neurodevelopmental disparities we observe between infants of African and European ancestries in Brazil are consistent with the large socioeconomic gaps by ancestry reported between households in Brazil during the time of our data collection. In 2006, about a quarter of self-reported Whites over 18 years of age were enrolled in undergraduate university, compared to 8.2% of individuals who self-reported as Black/Brown (IBGE, 2006). Similarly, average household income for self-reported Black/Brown population was about 44% of that of self-reported Whites.

3. Data Source, Sample and Measurements

The study employed data on two samples of 488 children born in Brazil and 630 children born in Argentina who had complete data on all study variables. Children between ages 3 months and 24 months were enrolled between 2005 and 2006 into the parent study providing

data for our analysis, which intended to assess the neurodevelopment of healthy infants. The children were recruited into the parent study during their well-child care visits to pediatric health facilities attended by physicians affiliated with that study (McCarthy et al, 2012). Given its focus on measuring neurodevelopment among healthy children, the parent study employed the following eligibility criteria for enrollment: singleton births with a birth weight $\geq 2,500$ gm, gestational age ≥ 37 weeks, and Apgar scores ≥ 6 . Infants with the following complications were considered ineligible and excluded from the parent study: using oxygen after birth, use of intensive neonatal care, stay in the hospital for five or more days after birth, chronic conditions requiring treatment for more than two weeks, report of major surgery or a prior diagnosis of developmental delay, and maternal complications during pregnancy. Parents of eligible children were consented into the study. This data sample has been used in several published papers investigating determinants of child neurodevelopment (e.g. Wehby et al, 2011a, Wehby et al, 2011c and Wehby, 2012).

The physicians who participated in the parent study were mostly pediatricians. They were identified through an epidemiologic and birth defect surveillance network in Latin American countries (Latin American Collaborative Study of Congenital Malformation known as ECLAMC; Castilla and Orioli, 2004). Physicians evaluated infants for eligibility during the time of the routine pediatric visit to their practices, and obtained information on health, demographics and socioeconomic from interviews with the mothers of the eligible infants. The same study and data collection procedures including the measurement of neurodevelopment were used by all participating physicians. All participant physicians received training in enrollment procedures, data collection, and assessment of neurodevelopment using a standardized instrument (described below) before the beginning of the study. The sample in this study was recruited from 11 pediatric clinics in Argentina located in 9 cities/municipalities (7 provinces), and 7 pediatric clinics in Brazil, located in 7 cities/municipalities (6 provinces) in Brazil. Despite its being a convenience sample, the sample descriptive statistics shown below indicate that it has extensive variation in demographic and socioeconomic characteristics. However, we discuss below generalizability issues. Further details on the parent study providing the data for our paper can be found elsewhere (McCarthy et al, 2012).

3.1 Outcome measures

Infant neurodevelopment including cognitive and receptive-expressive domains were assessed using the Bayley Infant Neurodevelopmental Screener (BINS), a standardized instrument designed to evaluate neurodevelopment of children aged 3 to 24 months (Aylward, GP. 1995). The BINS includes questions to assess infant's risk of neurodevelopmental problems in four domains of abilities: cognitive functioning, expressive functioning, receptive functioning, and basic neurologic functioning. As a screener of early neurodevelopment, the BINS has been shown to be strongly predictive of the child's performance on diagnostic instruments such the Bayley-II and the McCarthy Scales of Children's Abilities and to have good psychometric properties (Aylward 1995; Aylward and Verhulst 2000).

Our data come from the parent study discussed above, which assessed neurodevelopment in a sample of healthy children in South America (McCarthy et al, 2012). That study obtained data on neurodevelopment using the BINS translated into Spanish and Portuguese and administered to infants attending pediatric facilities for routine well-child visits by trained physicians (mostly pediatricians) who participated in the study. The study physicians received training in administering the BINS before initiating data collection. The test-retest reliability of the BINS in the parent study was 0.8–0.93 (McCarthy et al, 2012). The distributions of the BINS scores and reliability properties were comparable in that study to those based on the original US sample on which the BINS was normed. Lastly, there are no known racial/ethnic biases in the BINS.

According to age of the infants, the BINS includes either 11 or 13 questions about specific child activities. Each item is scored by the administering professional as 1 if the child performs the activity or 0 if not. Therefore, the total score may range between 0 (none of the activities are performed) and 11–13 (all activities are performed). Based on total score and the instrument's norms, a child can be assigned to a category of high or low risk of developing neurodevelopmental problems (Aylward and Verhulst, 2000).

We employed multiple approaches to define the outcome measures for neurodevelopment derived from the BINS data including overall neurodevelopment and domain-specific outcomes. The purpose was to ensure that we capture as much variation about child neurodevelopment as possible and evaluate whether disparities and potential channels vary between measures and domains. The first measure of overall neurodevelopment across the four captured domains (cognitive functioning, expressive functioning, receptive functioning, and basic neurologic functioning) was calculated as the total score of the child on a 100-point scale, representing the percentage of the maximum possible score given the child's age. For example, for a child who is 4 months and who passes 9 of the 11 items administered to the child, the score would be 81.8%. In addition to this percentage score, we constructed a binary indicator of high (1) versus low (0) risk for neurodevelopmental problems based on the instrument norms (Aylward, 1995, Aylward and Verhulst, 2000). We also computed total percentage scores in two separate neurodevelopmental domains: 1– cognitive and 2– expressive and receptive functioning. Similar to the total scores, the domain-specific scores were based on 100-point scale, reflecting the percentage of the possible maximum score for each domain given the child's age in months. Even though the instrument measured neurological functioning (neurological intactness and gross and fine motor skills), we did not analyze this as a separate domain due to its low variability in the sample (around 97% of the sample from Brazil and 99% of the sample from Argentina had a perfect score on this domain).

3.2 Ancestry

Measuring race and ethnicity is challenging in South American settings for several reasons. First, race and ethnicity are not clearly defined concepts and not commonly measured in survey or administrative data such as in the US. The concept of race is especially ambiguous in most South American countries and perceptions of race may vary widely between countries. For example, report of skin color in one of five categories (Black, White, Brown,

Yellow, or Indigenous) is explicitly used in the Brazilian census as an indicator of race. However, such a question is not commonly used in other South American countries such as Argentina. Furthermore, most South American countries such as Brazil and Argentina are highly racially and ethnically admixed. For example, within Brazil, race is perceived along a continuum of skin color rather than two or three categories. In contrast, skin color is less variable and the concept of race is more ambiguous in Argentina, where ancestry may be a more accurate indicator of perceptions of race or ethnicity.

Our dataset includes a question about the ethnic ancestry of the child based on maternal report. Mothers were asked to report the ancestries of the child from both parental lineages as far as the mother could remember. Specific ancestries were captured such as African, European, Native (all family generations as far as the mother remembers were born in South America), and other specific ethnicities. When the child had multiple ancestries (for e.g. both African and European), all reported ancestries were recorded. This measure of ancestry provides the flexibility of measuring racial and ethnic variation in settings where race and ethnicity are not defined along clear lines as in the US and can capture perceptions of both skin color as well as ethnicity/ancestry. This measure has been used in several previous studies using this dataset and other similarly collected data (e.g. Nyarko et al, 2013; Wehby et al, 2012a; Wehby and McCathry, 2013; Woodhouse et al, 2014; Wehby et al, 2015). The dataset included no questions of skin color or other questions about race or ethnicity.

Within each country, we focused on the most common ancestral groups for evaluating disparities in neurodevelopment. Four groups of ancestries were defined for Brazil: 1– African only (AO); 2– African plus other ancestries (AM); 3– Native only (NO); and 4– European only (EO). The first three groups were compared with the EO group. Other reported ancestries had low frequency to be separately analyzed. This measure of ancestry is expected to correlate well with measures of race based on skin color in Brazil (Nyarko et al, 2013). For example, African ancestry alone indicates that the mother reported that the child had African ancestry only and no other ancestries. In practice, this group is expected to mostly include individuals who would self-identify as Black in the Brazilian census. Similarly, the group of African plus other ancestries is expected to mostly include individuals who would self-identify as Brown based on the census question, while those of European ancestry alone would mainly include those who would self-identify as White.

The following three ancestral groups were most frequent in the sample from Argentina and were evaluated in our analysis: 1– Native only (NO); 2– both Native and European (NE); and 3– European only. The NO and NE groups were compared with the EO group. Unlike in Brazil, the ancestry measure in Argentina is less reflective of variation in skin color and more of ethnicity.

3.3 Covariates

Our models included several demographic and socioeconomic characteristics of the children and their parents and measures of household environment that are conceptually relevant for child development and supported several previous studies (e.g. Wehby et al, 2011a; Wehby et al, 2011b; Wehby and McCarthy, 2013). The demographic and socioeconomic indicators may proxy for parental preferences or abilities to invest in children. The child demographic

characteristics were age at the time of neurodevelopment assessment (dummies for age groups defined by the BINS instrument) and gender. Maternal demographics were age and marital status. Additional household demographic characteristics were number of child siblings (reflecting competition for parental time and resources but also potentially increased opportunities for the child to engage in playing activities) and total number of adults living in the household (representing number of individuals who could invest in the development of the child and generate earnings).

We included several economic indicators including maternal education and occupational status, household wealth, and whether child had health insurance coverage. Maternal education captures efficiency in investing in child health and development. Measures of maternal occupation activity and household wealth were included as proxies for income and earnings which are not measured in this data. The wealth variable was generated using principal component scores from aggregating multiple asset ownership and household quality conditions following previous studies using this data (Wehby et al, 2011a; Wehby and McCarthy, 2013).¹ Occupational activity also reflects time constraints in investment and childcare. An indicator for child health insurance status was included since it has also been associated with development (Wehby, 2014). Having insurance may enhance access to health services but may also result in an income effect by reducing out-of-pocket healthcare expenditures.²

Several measures were used to represent the household environment. The first was an indicator for whether the mother smoked during pregnancy, which has been shown to adversely affect child neurodevelopment (Wehby et al, 2011b) and serves as a proxy for risky maternal behaviors. We also included indicators about whether the father and grandparents were also reported as primary caregivers for the child (in addition to the mother) to reflect the availability of time to invest in child development; having grandparents as primary caregivers has been shown to be positively related to greater investment (Wehby et al, 2011a). Finally, we included several measures of household activities that reflect the amount of parental (and other household members') time and effort in investing in the child's development and that have been associated with child development (Wehby et al, 2011a). Specifically, we included indicators for the frequency (0, 1–2, 3+ times per week) of engaging the child in each of the following activities: reading to the child, the child playing with puzzles, blocks and board games, the child playing with sound producing toys, and the child watching TV.

We also assess whether geographic location can explain any of the observed neurodevelopment disparities. Geographic variation in population racial/ethnic composition is common due to racial/ethnic residential clustering and segregation in multiple settings,

¹The assets and household quality indicators were: owning a radio, television, refrigerator, and a car; employing a worker in the household; working on a family's agricultural land; source of drinking water; type of toilet; flooring material; roofing; and wall material; and number of household individuals per sleeping room. Certainly, some of these assets may have direct effects on development besides being proxies for wealth. For instance, having a TV may influence maternal knowledge about child investments. However, our main interest in these assets is aggregating their variation to generate a wealth index to investigate if household wealth mediates observed racial/ethnic disparities, rather than investigating their direct effects.

²Our aim is not to disentangle the various potential effects of insurance, but rather to examine whether it mediates any of the observed neurodevelopmental disparities.

partly driven by historical events. Economic/social conditions (e.g. neighborhood quality, safety, employment opportunities, access to groceries of fresh food products, healthcare facilities, etc.) are also known to vary widely by region. Area-effects have been previously shown to explain a sizeable fraction of racial disparities in low birth weight and preterm birth in Brazil (Nyarko et al, 2013).

We measure geographic location by indicators representing the municipalities where the children lived. Most children (over 80%) lived in the same municipality of the pediatric clinic where they were seeking routine care and were recruited into the parent study. Those children were assigned to the municipalities of their clinics. The other reported municipalities (outside of the clinic municipalities) had only a few children and could not be represented by a separate indicator for each non-clinic municipality due to their low frequency. These children were assigned into groups of “other municipalities”, each defined as a separate group of other/surrounding (non-clinic) municipalities for each clinic’s municipality. In other words, all children who were recruited at a certain clinic but lived outside of the municipality of that specific clinic were assigned into one group of other/surrounding municipalities, defined specifically for that clinic.

A total of 14 municipality areas were defined for the 8 clinics in Brazil (all children recruited in two clinics came from the same municipalities of these clinics). For the 11 different clinics in Argentina, 18 municipality areas were defined (two clinics were in one municipality, another two in the same municipality).

4. Econometric Framework

4.1 Main Models

Since the first objective of our study was to evaluate the “total” disparities in neurodevelopment by race/ethnicity, the first model was a regression of the neurodevelopment outcomes, one at a time, on the ancestry indicators defined above, controlling for child age and gender as indicated in the following function:

$$\text{Development} = f(\text{Ancestry}, \text{Age}, \text{Gender}). \quad (1)$$

The regression was estimated separately for each country using OLS. For Brazil, three dummy variables for the AO, AM, and NO groups were included with the EO as the reference group. Two indicators were included for the NO and NE groups (with EO as the reference group) for Argentina.

Next, our goal was to explore mechanisms that explain the observed racial/ethnic differences in neurodevelopment focusing on two main pathways: household-level characteristics, and area-effects. To do so, we also estimated two extended specifications of the child development function described above that added variables that are conceptually relevant for development and may vary by race/ethnicity and evaluated changes in the ancestry indicator effects on development. The second expanded specification focused on effects of household

characteristics including the socioeconomic and demographic factors and activities towards child development:

$$\text{Development} = f(\text{Ancestry, Age, Gender, Household Characteristics}). \quad (2)$$

The household characteristics added into Model (2) included all the household demographic and socioeconomic factors described above (maternal age and age squared, marital status, numbers of child siblings and adults in household, maternal education and occupational activity, and indicators for quartiles of the household wealth index). Also included were indicators for the childcare environment (indicators for father and/or grandparents as primary caregivers for the child) and the intensity of household investment in child development measured by the frequency of engaging the child in the four development-stimulating and playing activities described above.

The third specification added indicators for geographic location in the form of fixed effects for the municipality areas described above in order to capture area-level effects on disparities beyond the geographic variation in household characteristics:

$$\text{Development} = f(\text{Ancestry, Age, Gender, Household Characteristics, Area Effects}). \quad (3)$$

Finally, since variation in household characteristics such as parental educational attainment, wealth or health insurance status may be partly driven by geographic differences in economic and social conditions and in order to capture the total effects of the broader environment in which the child grows on racial/ethnic disparities, we estimated the following fourth regression specification that only adds the area fixed effects to the first basic specification:

$$\text{Development} = f(\text{Ancestry, Age, Gender, Area Effects}). \quad (4)$$

4.2 Robustness Checks

We estimated additional models to test the sensitivity of our estimates to different assumptions. Even though the sample includes only healthy children by design of the parent study providing the data, there is still variation in normal birth weight and gestational age. Both of these indicators are relevant for child development. To evaluate if the observed disparities in development are rooted in birth outcomes, we estimated model 1 adjusting for birth weight in grams and gestational age in weeks.

We also investigated whether the area-fixed effects were capturing examiner characteristics. As mentioned above, the examiners received training in administering the BINS and their reliability tested prior to data by comparing their scoring of the BINS on testing cases to a gold-standard. To evaluate if differences in the reliability of administering the BINS may have confounded any of the observed disparities, we estimated the basic specification controlling for the examiner's reliability score.³ Obviously, we could not include this

variable with the area-fixed effects since it is a fixed characteristic of the examiner. However, observing no changes in ancestry effects after adjusting for the reliability score would suggest that potential examiner variation in skill of administering the BINS is unlikely to explain the changes in ancestry effects that we are contributing to geographic location in models (3) and (4). We also added the examiner's sex to the specification adjusting for reliability to check for any potential demographic bias. We had no data on the examiner's race/ethnicity or ancestry.

5. Results

Before presenting the regression results, we provide a descriptive overview of the dataset. Table 1 provides descriptive statistics for the study variables. In the Brazilian sample, 21% of the children were considered to be at high risk of developing neurodevelopmental problems, while in the Argentina sample, 13% of the children were at this risk. The average total BINS scores were 83.0% in Brazil and 87.3% in Argentina; the average scores for cognitive functioning were 79.5% and 84.6%, respectively.

About 23% of the children in the Brazilian sample had AO ancestry and 35% had EO ancestry. In the Argentinean sample, 31% of were of NO only ancestry. About 50% of the children were males and average age was close to 11 months in both countries (ranging from 3 to 24 months). Several household demographic and socioeconomic factors were comparable on average between the samples from Brazil and Argentina.

5.1 Disparities in child neurodevelopment in Brazil

5.1a Main model results—Panel A in Table 2 reports the effects of the ancestry indicators on the total BINS score for Brazil in the four regression specifications described above.⁴ In all regressions, the reference category for the race indicators was EO ancestry. In the first basic regression which evaluates the total disparities by race controlling for child's age (dummies for 6 age groups) and gender (equation 1), children of AO ancestry had lower total BINS scores by about 5.8 points compared to those of EO ancestry ($p < 0.01$). This effect is fairly large, representing about 10% of the average total scores, and around 50% of the score standard deviation. Similarly, children of AM ancestry had lower total scores on average by about 5 points ($p < 0.01$) than those of EO ancestry. In contrast, the difference between children of NO and EO ancestries was much smaller and insignificant.

Controlling for household characteristics (demographics, socioeconomics, childcare, and investments) as shown in equation (2) reduces the disparities by about 46% (see Model 2 in Table 2). The average difference in total BINS scores between children of AO and EO ancestries decreases to 3.13 point and becomes marginally significant ($p < 0.1$). Similarly, the

³The reliability score was missing for two evaluators from Brazil and one evaluator from Argentina. Therefore, 99 children recruited by the two evaluators from Brazil and 33 children recruited by the evaluator with missing reliability scores were excluded from this analysis. We re-estimated model (1) for 389 children from Brazil and the 597 children in Argentina with examiner reliability data. We found the same results as in the full sample for Argentina. For Brazil, the disparities were larger in the subsample with reliability data especially for the cognitive domain and the indicator for being at high-risk for neurodevelopmental problems.

⁴Detailed regression results for model covariates are available from the authors upon request.

average difference in total scores between children of AM and EO ancestries drops to 3.31 points (still significant at $p < 0.05$).

Most interestingly, adding the area fixed effects to the model including household characteristics (equation 3) eliminates the observed disparities; the differences between children of African ancestry (AO or AM) and EO ancestry switch signs (become positive) and statistically insignificant (Model 3 in Table 2). Finally, the fourth specification that adds the area fixed effects to the basic regression (excluding household characteristics) also shows small and insignificant differences between these groups (Model 4 in Table 2).

A similar pattern of results is generally observed when measuring neurodevelopment by the binary indicator for being at high or low risk for developmental problems (Panel B in Table 2). Children of AO and AM ancestries were 21.5% and 18% more likely to be at high risk compared to those of EO ancestry (Model 1). Similar to the total scores, these gaps are large in magnitude and statistically significant. Adding household characteristics reduced these probability gaps to 16% for AO ancestry and 15% for AM ancestry, which were still sizeable and statistically significant (Model 2). However, the gaps substantially decreased and became insignificant after adding the area fixed effects with the household characteristics (Model 3). However, unlike the model for the total scores, adding the area fixed effects to the model excluding household characteristics reduced the disparities compared to the basic regression but did not eliminate them (Model 4). In that Model, children of AO ancestry were still 13% more likely to be at high risk than those of EO ancestry (difference statistically significant); similarly, children of AM ancestry were 9% more likely to be at high risk, although this difference was statistically insignificant. Similar to the total scores, there were no significant difference in risk status between children of NO and EO ancestries.

In Table 2, we also show the results from the same four regression specifications described above for scores of the two neurodevelopmental domains including cognitive and receptive-expressive development. In the basic specification (Model 1), children of African ancestry (alone or mixed) have lower scores on average than those of EO ancestry on both the cognitive and receptive-expressive domains. Adding household characteristics reduces these gaps which become statistically insignificant for AM ancestry on the cognitive domain and AO ancestry on the receptive-expressive domain (Model 2). Adding the area-fixed effects with the household characteristics eliminates these disparities (Model 3). Insignificant differences are also observed when adding the area effects without household characteristics in (Model 4) although the magnitude of differences on the receptive-expressive domain is noticeably larger for AO and AM ancestries compared to when household characteristics are also included.

5.1b Robustness Checks—The results from the Robustness checks that added covariates to the basic specification (Model 1) for the four neurodevelopment outcomes are reported in Table 4 for Brazil. A similar pattern of results is observed after adding birth weight and gestational age in the basic specification. These health indicators had overall no significant effects on the neurodevelopment outcomes; birth weight was (marginally) positively associated with the total neurodevelopment score, and with the cognitive and receptive-expressive domains, while gestational age was only (marginally) negatively

associated with the total neurodevelopment score. That these variables had no prominent impacts on neurodevelopment is not surprising since they represent variation in the normal range of these outcomes (birth weight 2500 grams and gestational age 37 weeks).

Adjusting for examiner reliability in administering the BINS (which was assessed prior to initiating data collection) and gender markedly attenuated the disparities observed in the total neurodevelopment score and the receptive-expressive functioning domain and made them insignificant. However, disparities were still observed between children of AO ancestry, MA ancestry, and NO ancestry compared to those of EO ancestry in the indicator for being at high risk for neurodevelopmental problems. The magnitude of the disparity for the AO group is remarkably close to that of the basic model based on the full sample without adjustment.⁵ Disparities in cognitive development were also observed for the AO group and the AM group after adjustment for examiner reliability and gender that were close in magnitude to those from the basic model based on the full sample.⁶

While these checks suggest that some of the results for Brazil are sensitive to adjusting for examiner reliability and gender, it should be noted that these variables did not have significant effects on all outcomes. Reliability was positively associated with neurodevelopment, but its effects were only significant for the total neurodevelopment score and receptive/expressive functioning. Reliability was marginally associated with high risk status only after adjustment for examiner gender and was not associated with cognitive development. Examiner gender was only marginally associated with worse neurodevelopment measured by the total neurodevelopment score and the high risk status but was not significantly related to the cognitive and the receptive-expressive domains. Therefore, as a whole, the results still indicate prominent disparities by ancestry in Brazil, especially in being at high risk for neurodevelopmental problems and in cognitive development, and that the area-effects that explain the disparities in these outcomes are not entirely driven by examiner skill or gender.

5.2 Disparities in child neurodevelopment in Argentina

5.2a Main model results—Table 4 lists the results for Argentina from the same models described above for overall neurodevelopment, comparing infants of NO and NE ancestries without those of EO ancestry. Both infants of NO and NE ancestries have significantly ($p<0.01$) lower total neurodevelopment scores than infants of EO ancestry by about 5 and 3 points, respectively (Table 4, panel A). Adding the household characteristics (Model 2) does little in changing these gaps which remain significant. However, adding the area fixed effects (Model 3) markedly reduces these gaps; however a marginally significant ($p<0.1$) of about 2.6 points is still observed between infants of NO and EO ancestries, suggesting that the included variables do not fully explain the gap between these two groups. To give a sense of

⁵Observing a larger disparity for the Native only group in the model for high risk status adjusting for examiner reliability than that of the group of mixed African ancestry in this model is primarily driven by limiting the analysis to the subsample with reliability data and not because of adjustment for examiner reliability and gender. Unlike the basic model for the full sample where the disparity for the group of mixed African ancestry is noticeably larger than that of the Native only group, the disparities are very close for these two groups when estimating the basic model (without adjusting for examiner reliability and gender) using the subsample with reliability data.

⁶The disparity in cognitive development for the Native only group was much larger in the subsample with reliability data than the full sample but was insignificant after adjustment for examiner reliability and gender.

the magnitude of the unexplained gap in total neurodevelopment scores, this difference is similar to that between being in the second versus the first quartile of household wealth. A larger gap in total scores between infants of NO and EO ancestries is observed when including area fixed effects without household characteristics (Model 4) than in the model including household characteristics (model 3), suggesting that these explain part of the gap independent of geographic differences.

Similarly, infants of NO ancestry have a higher likelihood of being considered at high risk of having neurodevelopmental problems by as much as 13 percentage-points than infants of EO ancestry (Table 4, Panel B, Model 1). The household characteristics explain little of this gap (Model 2). Adding area fixed effects (alone or with household characteristics) cuts the gap by nearly half and the remaining gap is not statistically significant. Unlike the case for the total scores, the difference between infants of NE and EO infants in being at risk of neurodevelopment problems was much smaller than that for NO infants and statistically insignificant; the difference was close to 0 when adding area effects.

Table 4 also shows the results for specific neurodevelopmental domains. The results for the cognitive and receptive-expressive domains are generally consistent with those for the total score but a few differences are worth highlighting. A large difference on the cognitive domain of about 10 and 6 points is observed for infants of NO and NE ancestries, respectively, compared to those of EO ancestry (Panel C). Unlike the total score model, however, adding the household characteristics slightly increases these gaps (Model 2). Adding the area effects, however, cuts the gap by nearly half for infants of NO ancestry (now insignificant) and entirely for infants of NE ancestry, similar to the total score.

For receptive and expressive functioning, adding the household factors slightly reduces the gap for infants of NO ancestry (Model 2, Panel D); adding the area fixed effects with the household characteristics reduces the gap further but it remains marginally significant (Model 3). However, adding the area fixed effects without household characteristics leaves most of this gap unexplained (Model 4). A smaller and marginally insignificant difference in receptive and expressive functioning is observed for infants of NE ancestry but it is mostly explained in the full model (Model 3).

5.2b Robustness Checks—We report in Table 5 the results from the Robustness checks for Argentina which added specific covariates to the basic specification (Model 1) for the four neurodevelopment outcomes. Similar to the results for Brazil, adjusting for birth weight and gestational age had practically no impact on the disparities reported in the basic specification. These health indicators had no significant effects on the neurodevelopment outcomes, except for a positive effect of birth weight on receptive-expressive functioning. Again, this is consistent with the sample including only children who are in the normal range of these birth outcomes.

Unlike the results for Brazil, the disparities reported in the basic model for the Argentinean sample were stable to adding the examiner reliability score for administering the BINS and the examiner's gender for all outcomes. Furthermore, the reliability score had inconsistent and generally insignificant effects across the various outcomes (e.g. negative coefficients for

the total neurodevelopment score, high risk status, and the receptive-expressive domain and positive coefficient for the cognitive domain). In contrast, children evaluated by female physicians consistently had scores indicating of worse neurodevelopment. However again, adjustment for these variables had no effect on the observed disparities in all evaluated neurodevelopmental outcomes, suggesting that the area-effects are not driven by skills of the evaluators or their gender.

6. Conclusions

This study explores differences in overall neurodevelopment and specific domains including cognitive and receptive-expressive functioning very early in life by ancestry in Brazil and Argentina, the two largest countries in South America. Understanding these differences is important given their implications for long-term disparities in health, human capital, and wellbeing and since early developmental deficits can be effectively targeted by cognitive and psychosocial interventions that have important positive effects on economic outcomes during adulthood (e.g. Gertler et al, 2014). We employ unique data collected using the same procedures from pediatric facilities in Argentina and Brazil that include assessments of cognitive and receptive-expressive neurodevelopment among children aged 3–24 months completed by trained physicians and rich maternal interview data about several conceptually relevant aspects of the household environment. To our knowledge, this is the first study of cognitive and receptive-expressive neurodevelopmental differences by race/ethnicity for separate countries in South America.

We found large disparities in early neurodevelopment in both countries. In Brazil, infants of African ancestry showed lagged cognitive and receptive-expressive neurodevelopment on average than those of European ancestry alone. In Argentina, children of Native ancestry ranked lower on these neurodevelopmental outcomes on average than those of European ancestry alone. However, these gaps were entirely explained for Brazil and largely explained for Argentina by differences in household characteristics and geographic location, suggesting that neurodevelopmental disparities in these countries are entirely driven by behavioral, social, and economic mechanisms operating both within the household and the broader environment in which the child grows.

Differences in geographic location by ancestry appear to be more relevant in explaining the observed disparities than household characteristics, suggesting an important role of the broader environment in racial/ethnic differences in neurodevelopment. These effects appear to be partly but not entirely mediated through the household environment. The large gaps in neurodevelopment by ancestry accounted for by the area-fixed effects suggest that racial/ethnic clustering and segregation in geographic location plays a key role in child development disparities in these two countries. Therefore, policies that reduce racial/ethnic residential segregation such as those that eliminate racial/ethnic discrimination in access to home loans and interventions to reduce geographic disparities in economic opportunities and social capital by improving the social and economic conditions of poor regions and neighborhoods may help to reduce racial/ethnic disparities in early child development.

Household characteristics partly explain some of the observed gaps independently of the geographic effects, suggesting that variation in household socioeconomic status and child rearing environment also play a role in explaining the observed racial/ethnic gaps in neurodevelopment. Therefore, parental preferences and abilities in investing in child development also need to be considered when designing policies and interventions to reduce racial/ethnic disparities in child neurodevelopment. Previous work has identified an important role for engaging the child in development-enhancing activities such as reading frequently to the child and engaging the child in playing activities (Wehby et al, 2011a). Therefore, increasing parental awareness and reducing their cost of providing these household interventions (such as by mandating that pediatricians counsel parents during routine well-child care visits about optimal household activities to enhance neurodevelopment and by subsidizing cost of child books for poor families) may help to lessen disparities in child development.

Despite its strengths, our study has some limitations that should be considered in future work. We are unable to examine other potential mechanisms for the observed disparities due to lack of data such as ethnic differences in nutrition (which can be driven by cultural factors or differences in access to healthy food) as well as the possibility of experiencing discrimination in access to social welfare, health, and loan programs. Evaluating these potential mechanisms in future studies is important for a more comprehensive explanation of these disparities. Another limitation is that the study samples were not random and were recruited at selective clinics. The convenience sampling of clinics and recruiting children during routine well-visits may not render the findings to be generalizable to the entire population. Also, the parent study providing the data for our study only enrolled “healthy” children. We are unable to compare the household characteristics of the sample to the populations of these countries since to our knowledge there are no national data on most of the detailed household measures that we employ for this age group. Similarly, we have no access to social and economic indicators for the communities of the study children and cannot directly evaluate the variation or representativeness of these characteristics. However, both samples had extensive demographic and socioeconomic variation (Table 1) and recruited from multiple locations within each country, making the results generalizable to at least a part of the population. Furthermore, observing ethnic disparities in neurodevelopment among children who do not have major health problems suggests that such disparities may even be greater among children who have physical, cognitive, and psychosocial health problems as the incidence and severity of these conditions may also vary by ethnicity.

Our results suggest an important role for area effects. However, as mentioned above, we have no measures of specific area conditions and are therefore unable to examine specific geographic mechanisms. Furthermore, since the sample was recruited in pediatric clinics that were mostly located in different cities within each country, it is possible that the variation that we are attributing to geographic differences may be driven by variation in testing between the physicians attending the clinics. However, this source of variation is unlikely since the study physicians received training in administering the BINS before data collection. Furthermore in robustness checks, we found that the disparities in high risk status and cognitive development in the Brazilian sample and all outcome disparities in the Argentinean sample remain after adjusting for the physicians’ reliability in administering

BINS, which was evaluated against a gold-standard benchmark before data collection, and for physician gender. We had no data on physician race/ethnicity to examine potential effects on neurodevelopment assessment. However, it is unlikely that any potential rater biases across the study pediatric facilities would be so systematic and strong to spuriously account for the racial/ethnic differences that are strongly explained by area effects in both countries.

With the available cross-sectional data, we cannot evaluate the dynamic effects and relationships of various household investments and specific socioeconomic conditions of the broader environment in influencing child development and racial/ethnic disparities. Analyzing these dynamic relationships with rich data on social and economic conditions of neighborhoods is needed to pinpoint the specific pathways leading to disparities, which would be most helpful for guiding specific policies and interventions to target these pathways. We are also unable to evaluate the long-term implications of the observed disparities. Furthermore, despite observing multiple household characteristics, we still lack data on other important variables such as income, which may play a different role from that of wealth (which we partly capture by the index based on household assets and quality indicators) in the production of early neurodevelopment (Blau, 1999). Understanding the role of income variation and parental preferences toward household consumption versus child investments is needed to shed light on the effectiveness of cash transfer policies or income based programs to reduce the observed racial/ethnic gaps in child neurodevelopment. Future research enrolling larger and nationally representative longitudinal samples and collecting rich data on child neurodevelopment, household environment, and social and economic conditions of neighborhoods very early in life and throughout childhood is needed to identify the specific mechanisms leading to racial/ethnic disparities in early neurodevelopment and how they change over time.

Our work indicates that commonly reported differences in labor market outcomes by race/ethnicity in South America may be rooted in racial/ethnic differences in early child neurodevelopment. For instance, the neurodevelopment gaps we find in Brazil are consistent with racial/ethnic differences in educational attainment and income in that country, where university attendance rate and household income among individuals of African ancestry are about 33% and 44% compared to those of European ancestry (IBGE, 2006). Given the importance of educational achievement for person-level socioeconomic outcomes as well as for economic development and for explaining economic differences between Latin American countries and the rest of the world (Hanushek and Woessmann, 2012), our work points to the need for future research on the long-run implications of the early gaps in child neurodevelopment that we find for educational achievement and labor-market outcomes in these countries.

In summary, we found large ethnic differences in overall child neurodevelopment and in cognitive and receptive-expressive domains in both countries. However, the gaps were almost entirely explained by household characteristics and geographic location, suggesting that they are driven by social and economic mechanisms and indicating that policies that decrease racial/ethnic residential segregation and improve social, economic, and physical environments across areas may reduce these disparities.

Acknowledgments

The collection of the data employed in this paper was supported by NIH grant U01 HD0405-61S1. This study was in part supported by NIH grant R03 TW0081180-01. The outcome data in this work are “derived from the Bayley Infant Neurodevelopment Screener. Copyright © 2004. Harcourt Assessment Inc. Used with Permission. All rights Reserved.”. Dr. Wehby thanks Dr. Eduardo E. Castilla and ECLAMC’s coordinators and physicians for their efforts in data collection and Drs. Jeffrey C. Murray and Ann Marie McCarthy for providing access to the parent study data.

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Table 1

Descriptive statistics of study variables

	BRAZIL			ARGENTINA		
	Obs	Mean	Stdev	Obs	Mean	Stdev
Outcomes						
Total neurodevelopment score	488	83.03	(13.57)	630	87.29	(12.73)
Indicator for being at high risk of neurodevelopmental problems	488	0.21	(0.41)	630	0.13	(0.34)
Cognitive functioning score	407	79.44	(27.98)	515	84.59	(26.87)
Receptive and expression functioning score	488	77.89	(18.46)	630	83.09	(17.29)
Ancestry (Brazil) (ref. European only)						
African only	488	0.23	(0.42)	NA	NA	NA
African mixed	488	0.26	(0.44)	NA	NA	NA
Native only	488	0.16	(0.37)	NA	NA	NA
Ancestry (Argentina) (ref. European only)						
Native Only	NA	NA	NA	630	0.31	(0.46)
Native European	NA	NA	NA	630	0.23	(0.42)
Control covariates						
Age dummies (ref age 21–24 months)						
Age 3–4 months	488	0.17	(0.37)	630	0.18	(0.39)
Age 5–6 months	488	0.13	(0.33)	630	0.15	(0.36)
Age 7–10 months	488	0.22	(0.42)	630	0.20	(0.40)
Age 11–15 months	488	0.2	(0.40)	630	0.17	(0.37)
Age 16–20 months	488	0.16	(0.37)	630	0.13	(0.33)
Male	488	0.50	(0.50)	630	0.49	(0.50)
Mother age	488	26.23	(6.40)	630	26.89	(6.49)
Mother age squared	488	729.13	(361.25)	630	765.03	(369.97)
Total siblings	488	0.88	(1.10)	630	1.14	(1.43)
Number of adults in the household	488	3.01	(2.09)	630	3.11	(1.92)
Wealth quantile (ref: 25%)						
Wealth quantile 50%	488	0.25	(0.43)	630	0.28	(0.45)
Wealth quantile 75%	488	0.20	(0.40)	630	0.23	(0.42)

	BRAZIL			ARGENTINA		
	Obs	Mean	Stddev	Obs	Mean	Stddev
Wealth quantile top 75%	488	0.25	(0.43)	630	0.24	(0.43)
<i>Mother education(ref less than primary school)</i>						
Completed primary school	488	0.14	(0.35)	630	0.2	(0.40)
Incomplete secondary school	488	0.15	(0.36)	630	0.26	(0.44)
Completed secondary school	488	0.26	(0.44)	630	0.29	(0.45)
Attended university	488	0.13	(0.33)	630	0.19	(0.40)
<i>Mother occupation (ref unemployed/stay home)</i>						
Low skill blue collar	488	0.11	(0.32)	630	0.06	(0.24)
Skilled blue collar	488	0.07	(0.25)	630	0.02	(0.15)
Independent worker	488	0.04	(0.20)	630	0.04	(0.20)
Clerk	488	0.05	(0.21)	630	0.13	(0.33)
Owner/Boss/Executive	488	0.06	(0.23)	630	0.07	(0.26)
Mother single	488	0.17	(0.37)	630	0.16	(0.36)
Mother in stable relationship	488	0.45	(0.50)	630	0.45	(0.50)
Mother smoke	488	0.10	(0.30)	630	0.15	(0.36)
Care provided by father	488	0.85	(0.36)	630	0.79	(0.41)
Care provided by grandparents	488	0.07	(0.25)	630	0.08	(0.27)
Private Insurance	488	0.13	(0.33)	630	0.33	(0.47)
<i>Reading to the child (ref= zero)</i>						
Once or twice a week	488	0.20	(0.40)	630	0.18	(0.38)
3 or more times a week	488	0.10	(0.30)	630	0.21	(0.41)
<i>Playing with sound producing toys (ref= none)</i>						
Once or twice a week	488	0.08	(0.27)	630	0.09	(0.29)
3 or more times a week	488	0.80	(0.40)	630	0.84	(0.37)
<i>Playing with board games/puzzles (ref= none)</i>						
Once or twice a week	488	0.076	(0.26)	630	0.10	(0.29)
3 or more times a week	488	0.13	(0.34)	630	0.36	(0.48)
<i>Watching TV (ref=none)</i>						
Once or twice a week	488	0.13	(0.33)	630	0.21	(0.41)
3 or more times a week	488	0.75	(0.43)	630	0.61	(0.49)

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	BRAZIL			ARGENTINA		
	Obs	Mean	Stddev	Obs	Mean	Stddev
Birth weight (grams)	488	3270.26	(443.00)	630	3353.12	(419.92)
Gestational age (weeks)	488	39.73	(1.11)	629	39.31	(1.00)
Interviewer reliability	389	0.87	(0.06)	597	0.82	(0.05)
Female interviewer	389	0.82	(0.38)	597	0.47	(0.50)

Notes: 1) The analysis includes 14 health facilities in 7 cities in Brazil, and 22 health facilities in 11 cities in Argentina; 2) All outcomes are derived from the Bayley Infant Neurodevelopment Screener. Copyright © 2004, Harcourt Assessment Inc. Used with Permission. All Rights Reserved ; 3) Missing variables occur for some children and some women. These missing values are not included for computation of the sample means and standard deviations in this table; 4) In the regression, observations with missing values are excluded from the analysis.

OLS estimates of the effects of ancestry on overall and domain-specific neurodevelopment for Brazil

Table 2

Control covariates	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)	Model 4 β (SE)
Basic controls	Yes	Yes	Yes	Yes
Households and demographics	No	Yes	Yes	No
Regional indicators	No	No	Yes	Yes
Panel A: Total neurodevelopment score				
African only	-5.75 (1.56) ***	-3.13 (1.73) *	1.66 (2.01)	-1.66 (1.89)
African mixed	-4.99 (1.50) ***	-3.31 (1.61) **	0.44 (1.98)	-1.66 (1.89)
Native only	-1.61 (1.76)	-1.51 (1.82)	3.86 (2.24) *	2.34 (2.10)
N	488	488	488	488
Panel B: High risk of neurodevelopmental problems				
African only	0.22 (0.05) ***	0.159 (0.05) ***	0.06 (0.06)	0.13 (0.06) **
African mixed	0.18 (0.05) ***	0.146 (0.05) ***	0.04 (0.06)	0.09 (0.06)
Native only	0.09 (0.05) *	0.09 (0.06)	0.0009 (0.07)	0.03 (0.07)
N	488	488	488	490
Panel C: Cognitive functioning score				
African only	-10.34 (3.66) ***	-8.79 (4.11) **	-0.41 (4.81)	-1.89 (4.39)
African mixed	-7.49 (3.51) **	-5.66 (3.76)	0.46 (4.72)	-0.4 (5.00)

	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)	Model 4 β (SE)
Native only	-2.04 (4.26)	-4.45 (4.52)	3.74 (5.48)	5.22 (4.93)
N	407	407	407	407
<i>Panel D: Receptive and expressive functioning score</i>				
African only	-7.00 (2.14)	*** -3.40 (2.36)	1.64 (2.79)	-2.99 (2.62)
African mixed	-6.30 (2.06)	*** -4.09 (2.19)	* -0.11 (2.75)	-2.99 (2.68)
Native only	-2.88 (2.41)	-2.36 (2.49)	3.67 (3.11)	1.12 (2.92)
N	488	488	488	488

Notes:

- ***
p < 0.01,
- **
p < 0.05,
- *
p < 0.10

1) Reference category is European only; 2) Basic controls includes age in months and gender; 3) Households and demographics include the following covariates: wealth index based on household quality/asset ownership derived from PCA; maternal education, maternal occupation, maternal age, maternal age squared, marital indicator, number of total child siblings in household, number of adults in household, whether mother smoke during pregnancy, indicator for father as a caregiver, indicator for grandparents as caregiver for the child, child having private health insurance, dummies for frequencies of reading to the child, frequency of the child playing with board games/puzzles, frequency of the child playing with sound producing toys, frequency playing with other toys, frequency of watching TV; 4) Regional variables indicate area fixed effects on municipality of child's location; 5) Standard errors in parentheses.

Robustness checks for OLS estimates of the effects of ancestry on overall and domain-specific neurodevelopment for Brazil

Table 3

Control covariates	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)
Basic controls	Yes	Yes	Yes
Birth weight and gestational age	Yes	No	No
Interviewer reliability	No	Yes	Yes
Interviewer gender	No	No	Yes
Panel A: Total neurodevelopment score			
African only	-5.4 (1.57)	*** (2.38)	-2.9 (2.41)
African mixed	-4.54 (1.52)	*** (1.88)	-2.51 (2.01)
Native only	-1.49 (1.76)	-1.28 (2.44)	-1.08 (2.44)
N	488	389	389
Panel B: High risk of neurodevelopmental problems			
African only	0.206 (0.05)	*** (0.08)	0.202 (0.08)
African mixed	0.168 (0.05)	*** (0.06)	0.122 (0.06)
Native Only	0.09 (0.05)	* (0.08)	0.149 (0.08)
N	488	389	389
Panel C: Cognitive functioning score			
African only	-10.07 (3.68)	*** (5.53)	-13.07 (5.66)
African mixed	-6.87 (3.68)	* (5.53)	-9.45 (5.66)
N	488	389	389

	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)
Native Only	(3.53) -2.38 (4.26)	(4.32) -8.58 (5.92)	(4.69) -8.3 (5.93)
N	407	323	323
<i>Panel D: Receptive and expressive functioning</i>			
African only	-6.56 (2.15)	-2.61 (3.32)	-1.74 (3.38)
African mixed	-5.71 -2.08	-3.58 -2.62	-2.18 -2.81
Native Only	-2.73 (2.40)	-0.03 (3.41)	0.2 (3.41)
N	407	389	389

Notes:

p < 0.01,

**
p < 0.05,

*
p < 0.10

1) Reference category is European only; 2) Basic controls includes age in months and gender; 3) Standard errors in parentheses.

OLS estimates of the effects of ancestry on overall and domain-specific neurodevelopment for Argentina

Table 4

	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)	Model 4 β (SE)
Control covariates				
Basic controls	Yes	Yes	Yes	Yes
Households and demographics	No	Yes	Yes	No
Regional indicators	No	No	Yes	Yes
Panel A: Total neurodevelopment score				
Native only	-5.09 (1.11)	*** (1.22)	-4.77 (1.43)	*** (1.29)
Native European	-3.19 (1.24)	** (1.25)	-3.13 (1.43)	** (1.30)
N	630	630	630	630
Panel B: High risk of neurodevelopmental problems				
Native only	0.13 (0.03)	*** (0.03)	0.12 (0.04)	*** (0.04)
Native European	0.05 (0.03)	0.04 (0.03)	0.002 (0.04)	0.01 (0.04)
N	630	630	630	630
Panel C: Cognitive functioning score				
Native only	-9.59 (2.64)	*** (3.03)	-11.47 (3.60)	*** (3.16)
Native European	-6.77 (2.85)	** (3.05)	-7.62 (3.57)	** (3.10)
N	515	515	515	515
Panel D: Receptive and expressive functioning score				
Native only	-5.5 (2.85)	*** (3.05)	-4.89 (3.57)	*** (3.10)
N	515	515	515	515

	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)	Model 4 β (SE)
Native European	(1.54) -3.14 (1.71)	(1.69) -2.78 (1.73)	(2.02) -0.99 (2.02)	(1.82) -1.35 (1.83)
N	630	630	630	630

Notes:

p < 0.01,
**
p < 0.05,
*
p < 0.10

1) Reference category is European only; 2) Basic controls includes age in months and gender; 3) Households and demographics include the following covariates: wealth index based on household quality/asset ownership derived from PCA; maternal education, maternal occupation, maternal age, maternal age squared, marital indicator, number of total child siblings in household, number of adults in household, whether mother smoke during pregnancy, indicator for father as a caregiver, indicator for grandparents as caregiver for the child, child having private health insurance, dummies for frequencies of reading to the child, frequency of the child playing with board games/puzzles, frequency of the child playing with sound producing toys, frequency playing with other toys, frequency of watching TV; 4) Regional variables indicate area fixed effects on municipality of child's location; 5) Standard errors in parentheses.

Table 5

Robustness checks for OLS estimates of the effects of ancestry on overall and domain-specific neurodevelopment for Argentina

	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)
Control covariates			
Basic controls	Yes	Yes	Yes
Birth weight and gestational age	Yes	No	No
Interviewer reliability	No	Yes	Yes
Interviewer gender	No	No	Yes
Panel A: Total neurodevelopment score			
Native only	-5.17 (1.11) ***	-5.88 (1.17) ***	-5.91 (1.13) ***
Native European	-3.19 (1.23) **	-3.24 (1.28) **	-3.71 (1.24) ***
N	629	597	597
Panel B: High risk of neurodevelopmental problems			
Native only	0.13 (0.03) ***	0.12 (0.03) ***	0.12 (0.03) ***
Native European	0.05 (0.03)	0.04 (0.04)	0.05 (0.03)
N	629	597	597
Panel C: Cognitive functioning score			
Native only	-9.48 (2.63) ***	-9.86 (2.73) ***	-10.02 (2.63) ***
Native European	-6.72 (2.85) **	-6.86 (2.91) **	-7.20 (2.80) **
N	515	489	489
Panel D: Receptive and expressive functioning score			

	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)
Native only	-5.68 (1.54)	-6.93 (1.6)	-6.96 (1.58)
Native European	-3.24 (1.7)	-3.2 (1.76)	-3.65 (1.73)
N	629	597	597

Notes:

- ***
p < 0.01,
- **
p < 0.05,
- *
p < 0.10

1) Reference category is European only; 2) Basic controls includes age in months and gender; 3) Standard errors in parentheses.