'Mommy, I miss daddy'. The effect of family structure on children's health in Brazil *

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Abstract

This paper studies the relationship between lone motherhood and children's height-for-age *z-scores* in Brazil. In order to isolate the causal effect between family structure and children's condition, we estimate a treatment-effects model that uses male preference for firstborn sons (as opposed to firstborn daughters) to instrument the probability of a woman becoming a single mother. We find that children being raised by a lone mother have a height-for-age *z-score* that is 0.31 points lower than that of children of similar characteristics that cohabit with both progenitors. We argue that the increasing trend of lone motherhood in Brazil should be treated as a major concern in health policy design.

JEL classification: I10, J12, J16
Keywords: lone motherhood, height-for-age *z-score*, Brazil, treatment-effects, children

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1 Introduction

The health of Brazilian children has constantly and significantly improved in recent decades. Data from the 2010 Census recorded that infant mortality in the first year of life had nearly halved in ten years. In 2000, for every thousand live births, 29.7 babies died before their first birthday, while the figure in 2010 was 15.6. Regarding anthropometric indices, stunting decreased during the period between 2003 and 2009 from 15.7% to 9.7% among white children and from 20.5% to 11.7% among blacks (Reis, 2012). This is an important achievement for the advancement of human capital investment as it is well known that early life conditions have persistent and profound impacts on an individual's later life in terms of chronic diseases, education and wages (see Barker, 1990; Almond and Mazumder, 2005, 2011; Almond and Currie, 2011; Currie and Vogl, 2012; Lin and Liu, 2014; among others).

The progress in maternal and child health that Brazil is achieving is the result of important changes over the last three decades in several domains. Brazil has experienced major economic growth with an increase in Gross National Income (GNI) per capita of 47.2% only between 2004 and 2012 (according to World Bank data). The financial gap between rich and poor has become less pronounced and cash transfer schemes (particularly *Bolsa Família*) have increased family income among the poorest groups. From an educational point of view, the major investment in elementary schooling during the 1990s has increased educational attainment among Brazilian mothers. In parallel, Brazil has experienced an important decline in its fertility rate. The country has also seen great improvements in terms of urbanization (access to water and sanitation).

Specifically in terms of health policy, in the late 1980s, a three-tiered healthcare system of private security, social security and charitable institutions was replaced by a universal, tax-funded, national health system. Primary health care became the cornerstone of the system, and the geographical targeting of care led to the setting up of family health teams in the neediest areas of the country. Moreover, maternal-child health policies in Brazil underwent profound change: a vertical health program that started in the 1980s, PAISM, for the promotion of breastfeeding, oral rehydration and immunizations, as well as the implementation of many national and statewide programs have improved children's health and nutrition (Paim et *al.*, 2011; Barros et *al.*, 2010).

Despite all the progress, the prevalence of stunting (1 out of 10 children) is much higher than in well-nourished populations, indicating that there is still room for improvement. Moreover, even if the Brazilian case can be thought of as a successful example, the speed of the improvement has not been uniform and important differences still remain. On a geographical level, differences between rural, urban and metropolitan areas continue to exist, which are mainly explained by the heterogeneity in sanitation and access to or quality of the health system. Despite convergence to a national standard level, the prevalence of stunting has been historically much higher in the poorest (North and Northeast) regions than in the wealthier Southeast. Also, although the racial gap in nutritional indicators has clearly decreased, white children still receive better nutrition than blacks (Reis, 2012).

While acknowledging regional and racial disparities, the main focus of this paper is to study the importance of family structure as a source of inequalities in children's health outcomes. Our hypothesis is that children raised by a lone mother are more likely to have lower height-for-age *z-scores* after controlling for other socio-economic and demographic characteristics than children growing up with both parents. Several mechanisms may

be at play. Lone mothers may suffer higher levels of stress because of the difficulties dealing with the role of sole carer and primary breadwinner. At the same time, lone mothers cannot count on the help and monitoring of a cohabiting partner. Similarly, they may have more difficulties obtaining care for their children because of a smaller extended family. All these mechanisms may explain the poorer health outcomes for children raised by a lone mother. As far as we know, this is the first time that family structure has been taken explicitly into account when analysing children's health inequalities in the case of Brazil.

If our hypothesis is confirmed, our results have important implications both for social and health policy. According to data from Brazilian Censuses, the number of children under the age of 14 that did not live with their father multiplied almost fourfold from 1980 to 2010. Indeed, in Brazil, nearly 1 out of 5 children between 0 and 13 years of age were raised by a lone mother in 2010. Historically, Brazil has had a high level of informal unions (which account for 36% of all unions in the most recent data). Also, it is common to have a child in each new union to fulfil the idea of having a *proper* family —this being particularly true for men who leave their children from previous relationships with the mothers (Greene, 1992). To this situation, we can add the violent context of high male homicide and incarceration rates (Murray et *al.*, 2013; Reichenheim et *al.*, 2011), which increase the probability of women rearing their children alone.

The isolation of a causal effect between family structure and children's health requires an econometric strategy that accounts for selection into marital status. We estimate a treatment-effects model that uses male preference for firstborn sons (as opposed to firstborn daughters) to instrument the probability of a woman becoming a single mother. Family economics literature has well established that firstborn children are more likely to cohabit with a father figure if they are boys than if they are girls (see Dahl and Moretti, 2008; Ananat and Michaels, 2008; Ayllón, 2014a). Assuming that the sex of a child is random and that there is no sex-selection abortion in Brazil (Chiavegatto Filho and Kawachi, 2013), the gender of the firstborn in a household allows us to implement an instrument variable strategy that, to the best of our knowledge, is used for the first time in the context of children's health analysis.

Our results indicate that children raised by a lone mother in Brazil have a height-for-age *z-score* that is 0.31 points lower than that of children of the same characteristics that cohabit with both parents. These findings are robust to different specifications that control for socio-economic and demographic characteristics. Moreover, the number of children in the household below the age of 10 and the mother's lack of schooling are factors associated with lower height-for-age *z-scores*. In turn, the mother's height and body-mass index are positively related with children's height (indicating to the importance of controlling for the genetic code). Our results confirm that family structure should not be overlooked when designing health policy in Brazil: lone motherhood may become a real challenge for future maternal-child health programs in Brazil (much more than racial or regional disparities).

After this introduction, the following section describes the acute consequences of malnutrition in early life. Section 3 discusses the relationship between children's malnutrition and family structure according to previous literature. Section 4 describes the dataset used and presents some descriptives while section 5 details the econometric strategy. Section 6 contains our main results and Section 7 concludes.

2 Malnutrition in early life

Malnutrition is typically caused by a combination of inadequate food intake and infections that impair the body's ability to absorb or assimilate food. It encompasses stunting, wasting, and deficiencies of essential vitamins and minerals, with obesity or over-consumption of specific nutrients as another form. From an economic perspective, infant nutritional status can be seen as the output of a health production function, where nutrient intake is a very important input. However, in addition to that and to the particular genetic variation, there are other relevant variables: appropriate care, household conditions (including food insecurity), parental education, access to quality health care and living environment.

There are two commonly used anthropometric indicators for children's nutritional status: *wasting* and *stunting*, which distinguish between short-term and long-term physiological processes (WHO, 1986). The first indicates a low weight-for-height and reflects current nutritional problems (diarrhoea, insufficient dietary intake and other childhood diseases). The weight loss associated with *wasting* can be restored quickly under favourable conditions and is generally seen as a short-lived problem.[1] The *stunting* index is measured by height-for-age and shows children's cumulative linear growth or a chronic restriction on their potential growth. It thus reflects the child's present and past inadequate nutrition and/or frequent illnesses, expressing a long-run health condition and is not usually reversible. The WHO recommends it as a reliable measure of overall social deprivation (WHO, 1986).[2] These indicators are measured in terms of a standard deviation *z-score* which accounts for the difference between the value for an individual and the median value of the reference population (same age and sex) divided by the same reference population's standard deviation.

Extensive epidemiological literature has focused on the early childhood environment, nutrition in particular, and its relationship with health outcomes in adulthood.[3] It emphasizes that linear growth failure is largely confined to the intrauterine period and the first years of life, and is caused by inadequate diet and frequent infections. Malnutrition in the early years of life may also cause later deficiencies in cognitive development. There is some disagreement as to whether the effects of malnutrition on cognitive development are more acute when the child is a baby (0-6 months), as Dobbing (1976) argues, or a toddler (6-36 months), but there seems to be a consensus that the first two years are very important (Waber et *al.*, 1981; Pollitt et *al.*, 1995; Martorell, 1995; Glewwe and King, 2001).

Early growth failure will lead to reduced adult stature unless there is compensatory growth in childhood (so-called *catch-up growth*), which is partly dependent on the extent of maturational delay that lengthens the growth period. Because maturational delays in low-income and middle-income countries are usually shorter than 2 years, only a small part of growth failure can be compensated. Individuals who remain in the setting where they developed childhood malnutrition tend to become short adults (Martorell et *al.*, 1994

[1] Glewwe et *al.* (2001) argue that weight-for-height can be useful for evaluating intervention programs because it quickly responds to changes in nutritional status.

[2] Weight-for-age is a third index, but it must be interpreted cautiously because of its inability to distinguish between *stunting* and *wasting*, and consequently between acute and chronic malnutrition. Because it is a combination of the other two indices, it does not distinguish between small but well-fed children and tall but thin ones. It also changes rapidly.

[3] This is known as the *fetal and infant origins hypothesis* and was developed by Barker (1990) who has argued that inadequate nutrition in uterus 'programs' the fetus to have metabolic characteristics that can lead to future diseases.

and 2005).[4]

The epidemiological literature reveals that the nutritional status of a woman before and during pregnancy is important for a healthy pregnancy outcome (Kramer, 1987; Kramer and Victora, 2001). Short maternal stature is a risk factor for caesarean delivery and low maternal body-mass index is associated with intrauterine growth restriction (WHO, 1995; Fishman et *al.*, 2004; Ronsmans et *al.*, 2006). In the short term, the results of maternal/child malnutrition are mortality, morbidity and disability. In the long term, the consequences are adult size, intellectual ability, economic productivity, reproductive performance, and metabolic and cardiovascular diseases (Black et *al.*, 2008).

Regarding academic achievement, particularly in developing countries, the economic literature has found that childhood malnutrition is a significant determinant of delayed enrolment and low test scores (Glewwe and Jacoby, 1995; Glewwe et *al.*, 2001; Alderman et *al.*, 2001; Wisniewski, 2010; Monk and Kingdon, 2010). Malnutrition in childhood can also undermine labour outcomes in adulthood because of the probability of low school attainment being greater for unhealthy children than for those who were well-nourished (Deaton, 2008).

In the Brazilian case, Machado (2008) showed that for children between 7-14 years old and from the Northeast and Southeast regions, low height-for-age status increases the chances of late entry into school. The study by Gomes-Neto et *al.* (1997) uses data from a major education intervention program, EDURURAL (conducted in three Northeastern states in the 1980s), which measured students' health. This program was designed to reduce low achievement and high drop-out rates in these rural areas. The authors studied the complementarities between health and educational attainment/cognitive proficiency of children and found that changes in nutritional status play an important role in explaining cognitive differences among children (but do not have an impact on the final degree of schooling).

More recently, Gigante et *al.* (2006) used a large cohort of data from all children born in the city of Pelotas (on the country's Southern region) in 1982, with follow-ups in adulthood (21-23 years old) to analyse various later health and economic outcomes. This study confirms that height-for-age predicts school or cognitive test performance in later life, and stunting between 12 and 36 months of age predicted poorer cognitive performance and/or lower school grades attained in middle childhood.

So, the previous literature has reached a strong consensus on the acute consequences of malnutrition during the first years of life across the whole life cycle. This paper assesses whether stunting (measured by height-for-age *z-score*) can be partly explained by family structure in Brazil.

3 Family structure and infant health: a review

Studies that have analysed the impact of marriage on health systematically find a positive association between the two. In general, the literature indicates that married people live longer, have fewer problems related to alcohol, engage in fewer risky behaviours and have better mental health (see Lillard and Panis, 1996; Espinosa and Evans, 2008; Rendall et *al.*, 2011; Curran et *al.*, 1998; Duncan et *al.*, 2006; Umberson, 1992; among others).

The literature has established that the marriage-health relationship can be explained

[4]Improvements in living conditions, such as those brought on through adoption, can trigger catch-up growth but do so more effectively in very young children.

by selection, causation or both.[5] According to the selection framework, healthier people are more prone to marriage because they are more desirable in the marriage market (e.g. physical attraction, mental well-being, higher income, greater self-sufficiency, likely longevity, etc.). In this case, it is not possible to attest that marriage itself provides a better health condition. So, the advantages observed in the health status of married people (compared to those without a partner) only reflect selection (Goldman, 1993).

On the other hand, the causation alternative advocates that marriage does cause benefits to the health of the people involved (adults and children). This is known as the *marriage protection hypothesis*, which sees marriage as a mechanism that protects people's health through: (i) social channels as integration, (ii) accomplishment of some social roles, (iii) support, (iv) financial resources and economies of scale, and (v) joint and full monitoring between spouses. The most common view is that marriage leads to emotional support: it is seen as an institution that gives a sense of meaning (or purpose) of responsibility/commitment to others, as well as closeness.[6] It also works as a sign of fulfilment of an adult social role, which together with parenthood reduces the chance of health-harmful and risk-taking attitudes (Ross et *al.*, 1990; Waite, 1995; Hibbard and Pope, 1993; Rendall et *al.*, 2011). Other factors include family income/wealth and economies of scale that may increase access to medical care and the purchase of better nourishment and housing (Becker, 1991; Hahn, 1993).

Despite the difficulties disentangling the influence of selection and protection, studies that have dealt with the issue are consistent regarding a marriage premium. They generally find that the association between marriage and health is a combination of both (Lillard and Panis, 1996; Murray, 2000; Rendall et *al.*, 2011), so marriage affects and is affected by its members' health status. Consequently, the positive results of marriage on health are also extended to the children living in two-parent families.

The monitoring mechanism is especially relevant when there are children in the household because they are treated as a collective good by both parents (Weiss and Willis, 1985).[7] In this case, any opportunistic behaviour by one of the parents is avoided by the monitoring between them, which may encourage both to invest in the common good. Theoretical models provide intuition for the empirical studies that have evaluated the effect of marriage on children's health through specific inputs, for example, quality/time of prenatal care, nutrition and/or abstention from tobacco, alcohol or illegal substances during pregnancy (Currie and Gruber, 1996; Joyce, 1999; Evans and Lien, 2005; Abrevaya and Dahl, 2008; Almond and Mazumder, 2011; Evans and Ringel, 1999). The findings indicate that the quality of care during the prenatal period, including the significance of the mother's nutrition, is very important for ensuring that the infant is born in healthy conditions, thus affecting the child's subsequent ability to accumulate human capital.

Moreover, despite the increased diversity of family arrangements, women are still disproportionately the primary caregivers for children in Brazil. As a result, women are more likely than men to be faced with the dual role when unmarried: that of sole caregiver and primary breadwinner. This situation affects access to resources and psychological well-being and must have an impact on the quality of care provided to children (Osborne et *al.*, 2012). A mother's stress (or depression) has a negative impact on her child's

[5]See Wood et *al.* (2007) and Ribar (2004) for extensive reviews of studies that relate marriage to adult's health and mortality as well as the impact of marriage on children's development outcomes (intergenerational health effects of marriage).

[6]This approach started with the seminal work by Durkheim (1951) on suicide.

[7]In empirical studies, children's quality may be represented either by their health condition or by some educational outcome.

health, not just in key periods such as pregnancy and breastfeeding but also during early childhood (Chung et *al.*, 2004).[8]

Regarding the father's involvement, some research suggests that it plays a role in linking family structure to children' health outcomes. Married and cohabiting fathers are more likely to be involved with their children by virtue of proximity, while men who are not married to or living with their child's mother find it harder to be involved, and hence participate less (Furstenberg and Cherlin, 1991). Besides, when a union dissolves, the father's involvement drastically declines (Tach et *al.*, 2010), especially if the relationship ends when children are very young. In general, the literature suggests that fathers may have an impact on infant health by encouraging (or not) women to seek prenatal care and refrain from unhealthy behaviours, such as smoking and consuming alcohol while pregnant (Teitler, 2001). Misra et *al.* (2010) have suggested that the father's involvement may improve birth and infant health outcomes by reducing maternal stress.

The relevance of each aforesaid mechanism is difficult to evaluate since they depend on the interaction between family members.[9] Therefore, no empirical study of the impact of family structure on children's development has succeeded in isolating each mechanism.

A significant number of empirical studies have examined the potential effects of family structure on children's development, and these generally confirm the disadvantage of children from households led solely by women.[10] Most of the literature focuses on cognitive and educational factors, as well as factors that are relevant during youth (early pregnancy, smoking, anxiety and economic inactivity). Studies that specifically analyse the impact of family structure on children's health indicate that unmarried mothers invest less in prenatal care and, consequently, their children have poorer indicators at birth. Thus, their children are at a disadvantage to others in terms of prematurity, birth weight and mortality (Bennett, 1992; Bennett et *al.*, 1994; Bird et *al.*, 2000; Peacock et *al.*, 1995).

However, few of these studies have addressed a causal relationship. The challenge for disentangling the effect of family structure on children's outcomes resides in the difficulty finding exogenous variations in the mothers' marital status. Ribar (2004) argues that in most studies the identification strategies used to address the issue of selectivity into marriage are unconvincing.[11] One of the most common methods used is that of instrumental variables, and it is usually found that exclusion restrictions reduce the association between family structure and well-being (which is consistent with selectivity) but do not eliminate the association (which is consistent with causality). Such is the case with Buckles and Price (2013), who measure the effect of marriage on four child indicators: low birth weight ($< 2,500$ grams), prematurity (< 37 weeks), mortality in the first year of life and the Apgar test. They use a sample of siblings to show that accounting for selection with regard to observable and time-invariant characteristics significantly reduces estimates of the marriage premium, but the positive causal effect remains.

This paper uses the instrumental variable method to analyse the causality between family structure and children's malnutrition (measured by height-for-age *z-scores*) by

[8] See Amato (2005), Fomby and Cherlin (2007) and Wu (1996) for further studies that have documented the adverse associations of family instability and child outcomes.

[9] Note, for example, that lone-mothers may also be exposed to some degree of monitoring by other family members (parents, siblings, etc.).

[10] For a literature review see Ribar (2004) and Sigle-Rushton and McLanahan (2004).

[11] It seems that the literature that analyses the impact of family structure on child outcomes (such as education or early adult results such as teenage pregnancy, tabacco or drug consumption) address causality more often. Some examples are Ermisch and Francesconi (2001), Finlay and Neumark (2010) and Craigie (2008).

proposing a new exclusion restriction that has not been previously used for a similar research question.

4 Data, definitions and descriptives

Data is from the Brazilian Consumer Expenditure Survey (*Pesquisa de Orçamentos Familiares*, POF) relative to the 2008-2009 period. The survey contains 190,159 individuals from 55,970 households and is representative of the population living in private households in Brazil. Our working sample is restricted to all (single-birth) children under 60 months of age that are sons or daughters of the head of household (or spouse), whose mothers are between 20 and 44 years of age (both inclusive) and did not have their child as teenagers. This last restriction is imposed because we do not want to confound the effect of teenage biological immaturity (which may have consequences on children's health outcomes) with that related to lone motherhood. Moreover, in the POF, family ties are defined in relation to the head of household: (i) spouse/ partner, (ii) child (son/daughter), (iii) another relative, or (iv) non-relative. Such a survey structure allows us to link 89.3% of the infants in the sample to their mothers. Children classed as 'another relative' (10.5%) or 'non-relative' (0.2%) cannot be linked to their mothers even if they are in the household.[12] As explained above, the 60 month threshold seems most appropriate when seeking to capture early-life health. In total, 10,072 records have been used.

The POF data contains anthropometric measures for all individuals (weight, height and length) as well as information on such characteristics as age, race, education, position in the family, availability of a private health insurance plan for each person in the family, household income, governmental cash transfers, living conditions (sanitation, street paving, public lighting, health facility in the community, quality of public services, violent area, etc.) and geographic variables (state and urban/rural areas).

Despite its importance, the raw anthropometric data collected by the POF is of limited value as an indicator of malnutrition in its own right, partly because weight and length/height depend on both age and gender. So, in order to assess the adequacy of a child's growth it is necessary to compare these indicators with their distribution in a "healthy" reference group and identify "extreme" or "abnormal" departures from the reference values.[13] To do this, the *Anthro* software created by the World Health Organization (WHO) was used, which requires input of each infant's sex, age in months, weight and length/height data.[14] From this data, *z-scores* for height-for-age have been calculated. Table 1 shows that the average height-for-age *z-score* is zero with a standard deviation of

[12]Strickly speaking, this means that our sample is not representative of all children under the age of 60 months in Brazil. However, it is also true that about 5% of children in this age group do not live with their mothers (according to the 2010 Census data) so, we are not missing as many mother-child links as it may seem. Also note that the restriction of mother's age is also related to survey structure limitations. By only using the sample of women between 20-44 we disregard the possibility of considering grandmothers that are rearing their teenage daughter's child.

[13]A total of 101 observations were considered extreme cases and were deleted from the final analysis.

[14]*Anthro* can be consulted at the web page http://www.who.int/childgrowth/software/en (June 2014). This software also provides the WHO Child Growth Standard measures for weight-for-age (WAZ), weight-for-height (WHZ) and body-mass index for age (BMI). Since 2006, the WHO has used new curves to assess the growth and development of children around the world. This new standard was obtained by combining longitudinal follow-ups from birth to 24 months and a cross-sectional survey of children aged 18 to 71 months. The sample has information from 8,440 healthy breastfed infants and young children from a wide variety of ethnic backgrounds and cultural settings (Brazil, Ghana, India, Norway, Oman and the USA).

1.70 and a minimum and maximum value of -5.99 and 5.92, respectively. Indeed, descriptives indicate that 11.2% of children in the sample suffer chronic malnutrition (*stunting*). On the other hand, 15.7% are obese.

Regarding family structure, a child's mother is considered to be a lone mother if none of the registered members of the household is her partner. This means that the lone mother may be divorced, separated, never married or widowed. As a matter of fact, the POF data does not make it possible to distinguish the mother's marital status.[15] In total, 9.6% of the children in the sample cohabit with a lone mother.

As in many other parts of the world, lone motherhood has become an increasing phenomenon in Brazil as shown in Graph 1, which uses data from the Censuses from 1970 to 2010 to create a sample with the same characteristics as those explained above. A thorough analysis of this trend goes beyond the scope of this paper but two explanations stand out in the case of Brazil. Firstly, the analysis by Greene and Rao (1995) indicates a squeeze in the Brazilian marriage market (a shortage of men) driven by a decrease in mortality rates. As, on average, men marry younger women, the simple reduction of mortality in younger cohorts increases the supply of women in relation to men. The result of this compression would be an increase in cohabitation, with men going through various unions during their life cycle.[16] Secondly, it is important to take into account how the Brazilian context of violence also increases the probability of a woman having to raise her children alone. Each year the country loses approximately 45,600 men lives due to homicides, according to data from the Ministry of Health (2010), which particularly affects young men. The same is true for incarceration rates.

The other rows in Table 1 show summary statistics for the groups of variables that will be used as controls when modelling the effect of lone motherhood on children's height-for-age *z-scores*: other demographic factors, children's and mothers' characteristics, household economic status, and regional/urbanization descriptives.

As for other demographic characteristics, summary statistics indicate that there are between 1 and 4 children in each household under 60 months of age (average 1.32) and that 43% of the children in the sample have at least a brother or sister between the ages of 5 and 10 and 24% between the ages of 11 and 15.

Regarding children's characteristics, 48.9% of the sample are girls; 51.1% are black, half-caste or indigenous and, on average, they are 32 months old. As for mothers' characteristics, mean age is 29.6 and mean age at birth is 27.4. Mothers' average height is 158 centimetres, their body-mass index is 24.8 and, they have been to school for an average of 8 years. 4% of the mothers have never been to school and nearly 18% of them did not complete primary education.

At least two of the mothers' characteristics are particularly important for the children's health: height and age at birth. Regarding mother's height, extensive literature highlights its correlation with some reproductive outcomes. Taller mothers tend to have easier births (Liljestrand et *al.*, 1985), heavier babies at birth (Kirchengast et *al.*, 1998), fewer stillbirths (Pollet and Nettle, 2008) and higher survival rates among their children. Thus, the mother's height carries direct information on genetic inheritance and indirect information about her own past situations of malnutrition and poverty.

[15] Throughout the paper, we use lone mother and single mother, irrespectively, to refer to women that are raising their children without a partner in the household, regardless of marital status.

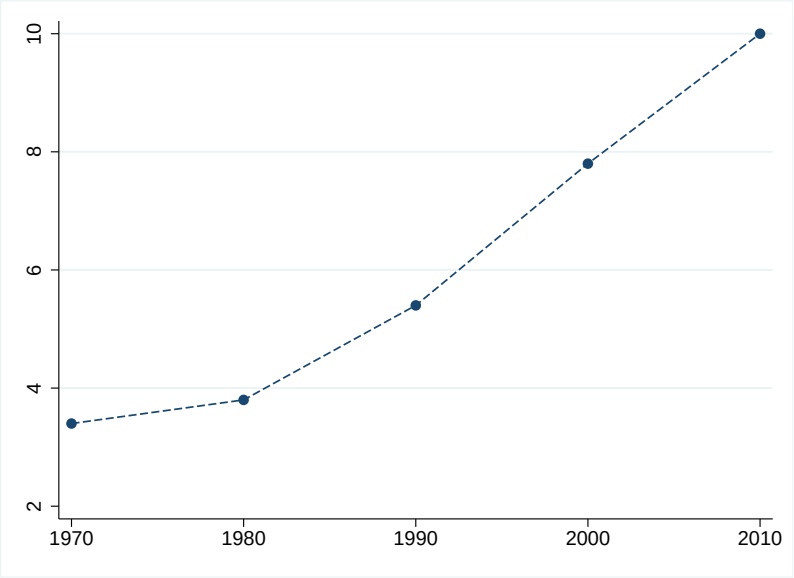
[16] A qualitative analysis by Greene (1992) showed that in Brazil it is common to have a child in each new union to fulfil the idea of having a proper family. A husband and wife may wish to have a child together regardless of the number of children either of them had before. This is particularly true for men who leave their children from previous relationships with the mothers.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.
Height-for-age *z-score* (*haz*)	0.002	1.707	-5.99	5.92
% in malnutrition (*haz* < -2)	0.112	0.315	0	1
% being obese (*haz* > +2)	0.157	0.364	0	1
Family structure				
Lone-mother	0.096	0.295	0	1
No. of children up to 60 months	1.320	0.534	1	4
No. of children up 5-10 years old	0.528	0.731	0	5
No. of children up 11-15 years old	0.311	0.633	0	5
Child's characteristics				
Girl	0.489	0.5	0	1
Black, half-caste or indigenous	0.511	0.5	0	1
Age (in months)	32.122	17.519	0	60
Mother's characteristics				
Age	29.647	5.964	20	44
Age at birth	27.427	5.993	17	44
Height (in cm)	158.953	7.018	130	188
Body Mass Index (BMI)	24.86	4.653	13.86	54.67
Years of education	8.125	3.957	0	15
Never at school	0.039	0.193	0	1
Primary school incomplete	0.178	0.382	0	1
Primary school completed	0.290	0.454	0	1
Secondary school completed	0.366	0.482	0	1
University degree	0.119	0.324	0	1
Household economic status				
In poverty	0.165	0.371	0	1
Receiving *Bolsa Familia*	0.231	0.421	0	1
log(income per capita)	5.754	1.016	1.244	9.572
Urbanization / regional characteristics				
Piped water	0.878	0.328	0	1
Paved street	0.595	0.491	0	1
North	0.099	0.299	0	1
Northeast	0.302	0.459	0	1
Southeast	0.143	0.35	0	1
South	0.142	0.349	0	1
Central West	0.078	0.268	0	1
N		10072		

Source: *Pesquisa de Orçamentos Familiares*, 2008-09. Author's computation. Weighted results.

Figure 1: Evolution of the percentage of children under 60 months of age cohabiting with their mother (20-44 years) with an absent father in Brazil, 1970-2010



Source: Own calculations on Brazilian Census Data, 1970-2010. Weighted results.

The information on the mother's age at birth is a measure of her biological maturity, which is another relevant factor for the child's health outcomes. Finlay et *al.* (2011) analyse the effect of the mother's age at first birth on infant mortality, its anthropometric failure (stunting and underweight), diarrhoea and anaemia. Using data from Demographic and Health Surveys (conducted from 1990 to 2008) for 55 low and middle-income countries, these authors found that the risk for the child's health is lower for women who have gave birth for the first time between the ages of 27 and 29. The risk of infant mortality in firstborn children from mothers below 27 and above 29 is higher, although the effect is only statistically significant for women below the age of 18.

The variables referring to household economic conditions are poverty status and being a *Bolsa Família* beneficiary. Poverty is defined using the same concept applied by the government cash-transfer program, *Bolsa Família*, which has been operating since 2003. This study uses the values that were established from June 2008 onwards: families with an income per capita up to 30 USD (monthly) are considered "extremely poor" and families with an income per capita above 30 USD but below 60 USD are considered "poor". Here the sum of these two groups defines a poor family. In the sample, 16.5% of the children live in a poor family and 23.1% receive the cash transfer.

It is important to note that the *Bolsa Família* is a secondary indicator of household poverty but also works as a health input control. Its inclusion was necessary for two reasons. First, because of its conditionality regarding the health of children up to 7 years old, which requires beneficiary families to monitor the vaccination card and make frequent visits to the doctor to follow-up the children's growth and development. This condition exposes all children whose families are beneficiaries (partially) to the same health input: access to medical services (prescriptions and monitoring).[17] Second, the *Bolsa Família*

[17]Women aged 14 to 44 years should also follow up and, if pregnant or nursing (lactating), should carry

and poverty status are both included (despite being based on the same criteria) because not every poor family receives this cash transfer (and vice versa).

In order to control for the level of urbanisation, we also consider the variables "piped water" and "paved street". The first is used as an indicator of sanitation conditions and the second as a *proxy* for the public services that come with urbanization. In the sample, 87.8% of the children live in an area with piped water and 59.5% with a paved street. As for regional characteristics, the Brazilian territory is divided into five areas (North, Northeast, Southeast, South and Central West). Most children live in the Northeast region of the country, followed by the Southeast and South.

5 Econometric strategy

The simplest modelling strategy to capture the relationship between family structure and child malnutrition would be an OLS regression accounting for changes in the outcome of interest according to a set of observable characteristics. Formally,

$$haz_i = \beta_0 + \beta_1 singlemother_i + \beta_2^{'} X_i + \epsilon_i \tag{1}$$

being haz_i the height-for-age *z-score*. As already explained above, among nutritionists, height-for-age is a widely recognized index to identify malnutrition. Among economists, it is the most useful indicator of a child's health and welfare in developing countries and is widely recognized as a good predictor of many later-life outcomes. Moreover, β_1 is the coefficient for lone motherhood which we expect to be negative thus indicating poorer health outcomes among children being raised by a single mother. X_i is the vector of explanatory variables, and finally, ϵ_i is the usual white noise error term.

However, a simple linear regression holds the assumption that the mother's marital status is an independent variable and that there is no correlation between the error term of the model that gives rise to the choice of mother's marital status and the error term in our equation of interest (ϵ_i). As a matter of fact, there are various channels by which the mother's marital status may be thought of as endogenous, and therefore, the estimates from equation 1 are inconsistent. As explained in the literature review, people choose whether they will partner or not and with whom, so marital status is a selection-into-treatment. Moreover, there are unobservable factors related to mothers' health that make an unhealthier woman more likely to be a single mother and which, in turn, affect children's health. If the error term in a model for becoming single mother is correlated with poor mothers' health, and the error term in equation (1) is correlated with this, the error terms are correlated. In this case, we have an omitted variable problem that yields biased OLS estimates.

In order to account for the bias, we fit an instrumental variables estimation, a treatment-effects model that will also restore consistency under the hypothesis of selection of unobservable factors. This is achieved with at least one instrumental variable that must be (directly) correlated with marital status and, at the same time, (directly) uncorrelated with the child's height-for-age *z-score* (the so-called *exclusion restriction hypothesis*). Thus we are interested in fitting the model:

$$haz_i = \beta_0 + \beta_1 singlemother_i + \beta_2^{'} X_i + \epsilon_i \tag{2}$$

out pre-natal tests and monitor their health and the baby's health.

$$singlemother_i^* = \alpha_0 + \alpha_1^{'} IV_i + u_i \tag{3}$$

where

$$singlemother_i^* = \begin{cases} 1, & \text{singlemother}^* > 0, \text{ i.e., mother is single, separated, divorced} \\ 0, & \text{otherwise} \end{cases}$$

and IV_i is the instrumental variable that needs to assign exogenous variation to the relation between mother's marital status and child's height-for-age. Expressed differently, we need at least one variable that influences the probability of a woman becoming a single mother that, at the same time, exerts no influence on her child's height-for-age *z-scores*.

In this paper, the instrumental variable is "firstborn girl". The family economics literature has shown the existence of a relationship between the probability of divorce or lone motherhood and the sex of the firstborn in a family. Dahl and Moretti (2008), Ananat and Michaels (2008), Bedard and Deschênes (2005) and Ayllón (2014b) have shown for the United States that firstborns are less likely to cohabit with a father figure if they are girls. In other words, firstborn girls (as opposed to firstborn boys) increase the probability of divorce or separation among natural parents and decrease the probability of their mother finding a new partner after dissolution of a partnership.[18]

Several hypotheses have been used to explain the association between partnership stability and firstborn males. First, it could be that men are (simply) *gender biased* and have a greater preference for raising boys than girls, which would explain why they are more likely to cohabit with their male offspring. Second, the *role model hypothesis* argues that fathers may believe that their sons are more in need of a male role model (than daughters) and that is why they are more likely to stay. Third, the *technological reasons* or *differential costs hypotheses* assume that men could be more efficient at raising boys than girls so, since it is easier for them, they are more likely to cohabit with their male children. This is similar to the idea that girls could be more costly in terms of money and time. Finally, the *compensatory behaviour hypothesis* assumes that boys have more health problems and are harder to look after than girls, so fathers are more likely to stay in the household to compensate.

We hypothesize that, like in the United States, "firstborn girls" (and all their brothers and sisters) are more likely to live without their father in Brazil than children in families where a boy is born first. Indeed, a simple regression probit with the dataset at hand confirmed that this is the case: firstborn girls are more likely than boys to live with a lone mother (with a significance level of 5%). We have confirmed these results with data from the five Brazilian Censuses from 1970 to 2010 extracted from the International Integrated Public Use Microdata Series (IPUMS-International) (see Minnesota Population Center, 2013). The significance level for the gender effect was even higher, which is readily explained by the fact that the Census contains a huge number of observations compared to the POF and therefore the gender effect can be more easily captured (Ayllón, 2014a).

It is important to note that results from the simplest regression model indicated that "firstborn girl" has no influence on the height-for-age *z-score* equation, which allows us to implement an instrumental variables strategy. To the best of our knowledge, this is the first time that such an instrument has been used in the context of child health analyses.

Mothers's previously imposed age limitations help us to ensure that the child observed to be the eldest really is the mother's firstborn. In Brazil, mean age at leaving home is

[18]Note that the same idea can be applied to widows. The death of a partner is a natural event that does not affect all women with the same likelihood. But we claim that once a woman becomes a widow, her chances of having a new partner are conditional on the sex of her firstborn child.

above 20, so it is unlikely for the firstborn in a family to have already left the parental home while the mother has a child that is younger than 6. Median spacing between children of the same mother below the age of 20 is 3 years (with an average of 3.4) according to Census data from 2010. Moreover, we assume that child sex is random (women cannot induce the sex of their babies) and that there is no sex-selection abortion in Brazil as confirmed by Chiavegatto Filho and Kawachi (2013).

6 Empirical results

Table 2 shows the results of the treatment-effects regression model. The first row clearly indicates that, controlling for other observable factors, being raised by a single mother is associated with lower height-for-age *z-scores* or, phrased differently, with a higher probability of suffering malnutrition, among children under the age of six in Brazil. The coefficient for lone mothers is statistically significant at 1%. Moreover, post-estimation results indicate that, conditional on being in a lone mother household, a child's expected height-for-age *z-score* is 0.31 points lower than for children in households with both parents. This is, for example, equivalent to the effect of being raised by a mother that never attended school.

The results of the second equation indicate the validity of the instrument variable used. Having a firstborn girl in the family increases the probability of a mother raising her children alone (statistically significant at 2%). The Wald test (shown at the bottom of the table) establishes that we can reject the hypothesis that the two error terms are uncorrelated. Moreover, a *likelihood-ratio* test of an over-identified treatment-effects system of interest against a just-identified version indicated the validity of the instrument used. Indeed, the "firstborn girl" dummy was not significant in the main outcome equation in any of the specifications we tried.

As for the other variables for family structure, the number of children in a household up to 10 years of age is associated with lower height-for-age *z-scores* in the studied sample, but not in the case of older siblings (11-15 years). It is reasonable to believe that malnutrition is more prevalent in families with a large number of children since food needs to be shared among more members.

Regarding the other explanatory variables, we focus first on children's characteristics. Being a female infant is positively related with higher height-for-age *z-scores* while being black, half-caste or indigenous does not have any explanatory power. Our results indicate that the nutritional racial gap is closing in Brazil once controlling for the endogeneity of family structure. Children's age (in months) is negatively associated with height-for-age *z-score*, which indicates that younger children are (in relative terms) taller than older children.

The mothers' characteristics offer some of the factors with the greatest explanatory power. Mothers' height is associated with higher children's height-for-age *z-scores* and the same is true for body-mass index. Both variables are keys in our specification as they control for the child's genetic code. As for the mother's age at birth: the older the mother was when she gave birth to the child, the higher her children's scores.[19] This association slightly reverses at older ages, following the usual inverted-U shape.[20] A mother's lack of schooling is another key variable for understanding children's height-for-age *z-scores* in Brazil. Compared to a child whose mother holds a University degree, a child with a mother that never went to school has a *z-score* that is 0.30 points lower. Note that no differences are observed between mothers that went to school (even for a short period). Moreover, children with an employed mother have higher than average height-for-age *z-scores*, although the coefficient is only statistically significant at 10%.

Household economic status was controlled by building a categorical variable that combined poverty status and receipt of *Bolsa Família* (BF). Poor children in Brazil that live in households that receive *Bolsa Família* are still suffering consequences for their health condition because their family cannot provide sufficient economic resources. Despite the *Bolsa Familia*'s success at fighting poverty in Brazil, poor children in beneficiary households have lower height-for-age *z-scores* compared to those not receiving the transfer.[21] Also, household income per capita was considered (in logs) but was not statistically meaningful.[22]

[19]Note that despite our initial hypothesis that taller women could have had better chances in the marriage market (and, therefore, be less likely to be a lone mother), the variable "mother's height" was not statistically significant in explaining single motherhood.

[20]Mother's age was not included in order to avoid multicollinearity problems.

[21]If households are no longer considered poor thanks to the BF transfer, this would indicate major success of the program, by not only helping families out of poverty but also their children out of malnutrition.

[22]We also tried to include household income quintiles but this made no difference to the results so they were left out of the final specification.

Table 2: Coefficients for the treatment-effects model on heigh-for-age *z-scores* in Brazil, 2008-09

	Height-for-age z-score equation		
	Coefficient	Std. error	P-value
Family structure			
Lone-mother	-2.107	0.221	0.000
No. of children up to 60 months	-0.128	0.060	0.034
No. of children 5-10 years old	-0.123	0.042	0.004
No. of children 11-15 years old	0.004	0.043	0.921
Child's characteristics			
Girl	0.155	0.053	0.003
Black, half-caste o indigenous	-0.034	0.058	0.559
Age (in months)	-0.037	0.006	0.000
Age^2 (in months)	0.000	0.000	0.000
Mother's characteristics			
Height	0.030	0.004	0.000
Body Mass Index (BMI)	0.022	0.005	0.000
Age at birth	0.496	0.266	0.063
Age at birth^2	-0.015	0.009	0.095
Age at birth^3	0.000	0.000	0.135
Ref. University degree			
Never at school	-0.305	0.154	0.048
Primary school incomplete	-0.172	0.119	0.149
Completed primary	-0.142	0.113	0.209
Completed secondary	-0.070	0.096	0.466
Employed	0.106	0.055	0.056
Household economic status			
Ref. 'Not poor, not receiving BF'			
Not poor, receiving BF	0.060	0.076	0.426
Poor, not receiving BF	0.045	0.146	0.755
Poor and receiving BF	-0.191	0.107	0.074
log(income per capita)	-0.041	0.042	0.330
Urbanization / regional characteristics			
Piped water	0.076	0.069	0.269
Paved street	0.119	0.053	0.027
Ref. Southeast			
Northeast	0.047	0.074	0.523
Northt	-0.123	0.084	0.142
South	0.073	0.081	0.366
Central West	0.026	0.084	0.759
	Lone-mother equation		
Firstborn girl	0.166	0.066	0.012
$ln - L$	-21667236		
ρ	0.529		
Wald test of independent eq. (ρ=0); $\chi^2(1)$= 47.01 ; Prob > χ^2 = 0.0000			

Source: Pesquisa de Orçamentos Familiares (POF), 2008-09; authors' computation. Standard errors allow for intragroup correlation (children having the same mother).

In terms of the level of urbanization, the results show that living in an area with paved streets is positively related with higher height-for-age *z-scores* while piped water does not have any explanatory power. As for regional characteristics, and unlike the previous literature, we do not find statistically meaningful differences across regions once controlling for other characteristics and the endogeneity of family structure.

Other variables were included in the specification to test their importance for height-for-age *z-scores* but they do not yield statistically significant results and were left out of the final specification. These include living in an urban area, whether the child has a private insurance plan, sewage disposal in the household, mail delivery service, dangerous location in the sense of being close to a dump, sewer, polluted river or a hill subject to sliding, garbage service, street-lighting and household's perception of the quality of the health service. Note that the inclusion of none of these variables (or groups of them) made no difference to the main results.

6.1 Robustness checks

One possible drawback of the estimation strategy presented above is the fact that for a certain number of children in the sample the explanatory variable "girl" in the main equation and "firstborn girl" in the auxiliary equation refer to the same child. In order to confirm our results, we have run the same specification but excluding firstborn children (thus from second order onwards). The results were very similar to those presented in Table 2: lone motherhood is associated with lower height-for-age z-*scores* with a coefficient of -1.89 (rather than -2.10) and statistically significant at 1%. Similarly, "firstborn girl" is associated with lone motherhood with a level of significance of 3% and a coefficient of between 0.169 (rather than 0.166). These results confirm that our findings are not dependent on the child's order of birth, and neither is the instrumental variable strategy.[23]

7 Conclusions

This paper has studied the causal relationship between family structure and children's health conditions in Brazil. In particular, we assessed whether lone motherhood has any influence on the height-for-age (*z-score*) of children under the age of 6. Using data from the *Pesquisa de Orçamentos Familiares* collected between 2008 and 2009, we find that children being raised by a lone mother have a height-for-age *z-score* that is 0.31 points lower than that of children of similar characteristics that cohabit with both progenitors. The results are robust to different model specifications and are the outcome of an instrumental variable econometric strategy that has been used for the first time in the context of child development analysis. More precisely, we use male preference for firstborn sons (as opposed to firstborn daughters) to instrument the probability of a woman becoming a single mother. Robustness checks also indicated that the results are not dependent on children's birth order.

The mechanisms that help to understand the positive relationship between stunting and lone motherhood in Brazil, while controlling for other socio-economic and demographic factors, are difficult to disentangle. The previous literature has indicated that

[23]We hypothesize that the small reduction in the coefficient for lone motherhood may indicate that second and higher order children are slightly less affected by family structure because lone motherhood may have occured in these households more recently. However, the dataset at hand does not contain information about when the mother started to raise her children alone.

lone mothers probably suffer higher levels of stress given the need to deal with the dual role of sole carer and primary breadwinner.[24] Stress may affect women's capacity to care for children and therefore child development may be jeopardised. Lone mothers also lack monitoring by a cohabiting partner that could, for example, dissuade her from health-harmful and risk-taking attitudes with regard to the child. Finally, women that raise their children on their own may have a smaller extended family and also fewer social relations (due to the amount of time and energy that needs to be devoted to childcare) and, as a result, may find it harder to seek or obtain help (in all domains).

Our findings indicate that lone motherhood should be a major concern for health policy design in Brazil. As in other parts of the world, each year, more and more children are being raised by a lone mother. Moreover, our results are probably highly conservative as we have intentionally not considered teenage mothers in order not to confound biological immaturity with lone motherhood (Finlay et *al.*, 2011). Health policy designers in Brazil should not only focus on the (shrinking) inequalities by region or race but should also shift their attention to the (increasing) inequalities by family structure.

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[24]For example, Paxson and Waldfogel (2002) found for the United States that higher levels of absent fathers, especially absent fathers and working mothers, were associated with higher rates of child maltreatment.

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