Patterns of sex differentials in child mortality in Brazil (2000-2010)

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Introduction

Infant and child mortality (up to age 5) are known –for a number of reasons– as valuable indicators of living conditions in a population. In the case of Brazil, committed to comply with the Millennium Development Goals, UNICEF recognizes the efforts made to improve these conditions by increasing survival rates among children under five years old. In fact, Brazil is one of the five nations with the sharpest annual reduction in mortality for these ages during the first decade of this century (UNICEF, 2012). While the dramatic decline has located Brazilian infant mortality around 15 per thousand in the period 2010-2015, it is unknown whether the increases in survival have benefited boys and girls equally.

In this context, the breakdown of estimates by sex –besides of allowing to measure gender differences– can greatly contribute to the understanding of the socioeconomic phenomena underlying the evolution of infant mortality toward low levels. Considering that equity in health and survival are important policy issues and differentials by sex are one of the areas requiring special focus, United Nations made important efforts to fill this gap (UN, 2011).

Having in mind that we do not have enough evidences of the Brazilian child mortality sex differentials, particularly for the past, this paper articulates a range of data to depict that pattern. They point to what is believed to be a pattern of differentials by sex tending to shrink as mortality levels at early ages goes down. This pattern would prevail in the current scenario of dramatic decrease in infant/child mortality in a developing population context.

We firstly show the trend of infant mortality and the population sex ratio at early ages to contextualize evolution of the sex mortality differentials.

Secondly, we consider evidences of these differentials at early years of life using the proportion of surviving children and mortality rates from deaths reported in the last Brazilian household censuses. We also include measures from vital statistics. Finally, empirical models such as Life Tables from Coale and Demeny (1966) and the United Nations (1982) and a wide range of international vital statistics are used for comparison purposes.

1 This research has the support of the Brazilian National Council for Research and Technology (CNPq).
2 CEDEPLAR/FACE/UFMG - Brazil
The data sources for Brazil are, essentially, the 2010 Census and vital statistics on live births and infant deaths for the period 2008-2011.

1. The context: infant mortality (IM) levels and pattern of sex ratios (SR) at the early years of life over the last decades

Infant Mortality in Brazil was experiencing a continuous decline before entering second half of the XX century. Figure 1 shows the evolution of this indicator among its five geographic regions over the last eighty years. The social development in those regions, it is important to say, has, as expected, a strong relationship with the IM levels showed.

In the first half of the last century levels were with few exceptions over 100 deaths per thousand live births. Although steadily declining in the eighties, this trend has been even more pronounced in the last 20 years. Currently it is estimated that Brazilian IM is situated around 15 per thousand; there are regions with IM around 10 per thousand as it is the case in the South and Southeast, both known for having the highest socio-

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3 Table A1 in Annex shows selected socioeconomic indicators by geographic Brazilian regions. Ranking of these regions, starting from lowest household income, for instance, is: 1) North East; 2) North; 3) Mid West; 4) South; 5) South East.
economic development and reliable demographic data within the country. IM in the poorest Region (North East) is located above 15 per thousand. There are not researches on infant mortality by sex available. It is worth to say, also, that Brazil follows the average Latin American and the Caribbean trends. (See Figure A1 in Appendix).

Patterns of sex ratio (SR) at the early years of life

It is known that, with few exceptions due to generally exogenous interventions, the male mortality tends to be higher than female mortality vis-à-vis age. This pattern is present even before birth; estimates for fetuses SR, since when sex is possible to recognize, surpasses by far male/female equilibrium. Data collected in the eighties confirm the presence of more than 150 male fetuses per 100 female fetuses (Kellokumpu-Lehtinen and Pelliniemi, 1984; Byrne et. Al., 1987). More recent data for gestational age around 16 weeks, show that they may have a SR around 2.0 (Skjaerven and Vatten, 2004).

Sex ratio at birth ranges, traditionally from, say, 103 to 106. This is valid in a society without discrimination against female (or male) babies. As mortality risks tend to be higher for men since birth, or before, it is expected that the SR in a cohort tends to decrease as the age increases, except for situations like a strong gender preferences or selectivity in children migration.

Taking into account children under age 10, we observe that the SR decreases as age increases in countries classified by the UN as "more developed" over the period 1950-2010. In this category of countries we also observe that the SR, at the same age, tends to increase over time, indicating that declines in mortality have benefited, proportionately more, male children. Overall, if considered period statistics we hardly observe increased SR by passing the 0-4 age group to the next. The opposite is observed in populations known to have a strong preference for male children, such as China, Taiwan, India and other Asian countries.

Given this pattern, Brazilian census present a different trend. Figure 2 shows the SR for the period 1970 to 2010 for the whole country and according urban or rural residence. The series is presented up to age 9, for ages grouped 0-1, 2-4, 5-7 and 8-9 years in order to minimize distortions caused by age errors and to better visualize the age trend. By considering the rural and urban residence we assume no selectivity in migration flows for children below age 10. We believe it is a robust assumption for the Brazilian population.

Firstly, we observe that value of SR raises over time; this is observed for the total population and even when classified according to urban and rural residence. With some

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4 Data not shown - Demographic Yearbook USND and Demographic Statistics - http://esa.un.org/unpd/wpp/Excel-Data/population.htm

fluctuations, for any given age at any given year, the more recent the census the higher the SR value. Another important peculiarity to be noted is that SR, generally speaking, does not decrease as age increases as it has been normally observed all over the world. This is true for the total population and it is clearer for three out of the five censuses (1980, 1991 and 2010). This historic trend is also suggested in other census' countries for SR before age 10: in Costa Rica, when comparing data from 1984 and 2000, we found that SR tends to increase as age increase in both censuses. Also, at any given age, SR tends, in general to be higher in the latter year than in the in the former. Similar pattern although less evident is found in Argentinean censuses for years 1980 to 2001: SR by age, between ages 4 and 10, does not decrease (See figures A3, in Annex).

When considered the urban/rural breakdown, we notice that rural population is the major responsible for this trend. Despite the small share of the rural population (44% in 1970 to 16% in 2010), it is the intense increase of the SR by age at any given census, which defines the national trend. In the case of the 2010 census, SR at ages 0-1 is near 1,03; at ages 8-9 the value is above 1,06.

**Figure 2**

_Brazil (total, urban and rural) - 1970-2010: Sex ratio by age (0 to 9 years old)_

We note in the urban area, despite some fluctuations, an increase in the SR by age over the four decades thus a certain parallelism is also observed between censuses. This could mean a relative higher increase of survivorship among boys in the first age
interval (0-2 years in this case). After that age, gains in survival, if any, would have result approximately in the same proportion for both sexes. Differently, in the rural area, besides the increases in the SR, this indicator also increases as age increases. The pattern of the curves suggests proportionally more gains in survival among boys at all age groups up to age 10 in the rural area.

As it was shown, Brazil has experienced a general decline in infant mortality with sharper decline over the last four decades. Decline applies also to the under five mortality. Consequently, the increase in the SR during this period denotes a higher increase in the survivorship among boys than among girls.

Trend by age can not be attributed to migration flows; on one hand because we do not have evidences of migration sex selectivity for children below these ages and on the other hand because movements in one area would reflect in the other one.

Figure 2 suggests that in the period considered –where, as mentioned, there has been a decrease in the child mortality levels– this improvement would have benefited more the boys than the girls in rural areas. This trend was present, surprisingly, in nearly all Brazilian Federal States: increases in the SR from one census to the next, being, this pattern, more accentuated in the rural area. Annex includes the SR for population below age 10 for selected geographic regions of the country (Figure A2).

2. Recent evidences of the sex differentials in child mortality in Brazil

To advance in the discussion of the above suggested hypotheses, indicators of infant and child mortality by sex are given. Sources for analyzing this phenomenon are Brazilian censuses, using indirect and direct techniques and vital statistics using the Brazilian Health Statistics Systems SINASC and SIM (for live births and deaths, respectively).

2.1 Sex differentials in child mortality estimated using census data

Regarding the census, we use information on children ever born (CEB) and surviving children (SC) disaggregated by sex; the latter is acknowledged to be an indirect and reliable indicator of mortality, meanly at early years of life. We use the Brass technique (Brass and Coale, 1968) that allows us to transform the proportion of SC from women up to age 30, into probabilities of death between birth and ages 2, 3 and 5. These estimates are referred, roughly speaking, to the previous five-years of the Census date.

Table 1 shows the complement of the SC proportions, i.e, children dead by sex referred to the years 2000 and 2010 and the probability of death from birth to age x indicated.

Although we are not interested, here, in the measurement of the child mortality level, it is worth to emphasize the significant decrease of this phenomenon in a short period of

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10 years. Just one example: women aged 20-24 years reported in 2000 that 3.6% and 3.1% of sons and daughters, respectively, had died. In 2010, the proportion equates to something around 1.7%. A decrease of similar magnitude was found among the children of women in other age groups. This decrease is reflected accordingly in the corresponding probabilities of death. Last panel of Table 1 shows that decrease in any mortality indicator is more accentuated among boys than girls – above and below 50% respectively– regardless age’s mother. Against the argument that this trend is result of random variations, it is worth to note that this pattern is present in the five geographic regions.

### Table 1.

**Brazil, 2000 and 2010: Proportion of children dead, death probabilities and male to female mortality ratio (MFMR) estimated from census data**

<table>
<thead>
<tr>
<th>Mother’s Age group</th>
<th>Proportion of children dead</th>
<th>Death probability between age 0 and x*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td>15-19</td>
<td>0.036</td>
<td>0.031</td>
</tr>
<tr>
<td>20-24</td>
<td>0.036</td>
<td>0.031</td>
</tr>
<tr>
<td>25-29</td>
<td>0.039</td>
<td>0.033</td>
</tr>
<tr>
<td>30-34</td>
<td>0.046</td>
<td>0.039</td>
</tr>
</tbody>
</table>

| 15-19              | 0.0174 | 0.0168 | 1   | 0.0166 | 0.0160 | 103.8 |
| 20-24              | 0.0165 | 0.0170 | 2   | 0.0164 | 0.0170 | 96.6  |
| 25-29              | 0.0171 | 0.0168 | 3   | 0.0168 | 0.0166 | 101.7 |
| 30-34              | 0.0209 | 0.0203 | 5   | 0.0207 | 0.0201 | 102.8 |

<table>
<thead>
<tr>
<th>Relative variation over the period 2000-2010 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
</tr>
<tr>
<td>20-24</td>
</tr>
<tr>
<td>25-29</td>
</tr>
<tr>
<td>30-34</td>
</tr>
</tbody>
</table>

* Estimated using Brass technique on surviving children  
Source: IBGE Foundation, Demographic Censuses - 2000 and 2010 (micro data)

Related to the child mortality differential by sex, we use the ratio of the male to female mortality (MFMR). (Last Column in Table 1).

There is effectively –consistent with the SR before analyzed– a decrease in the ratio over the period 2000-2010 (last column of third panel in Table 1). Furthermore, given historic experiences, one would expect increases in MFMR by age, which in a way is the case for these series if the child’s age 2 is the starting point. What is important to note here is that MFMR clearly decreases from one period to the next one in all cases. There is almost no excess of male over female mortality in 2010. Moreover, mortality for age 2, originated from mothers at age 20-24 –where women's answer is considered as the most reliable– accuses excess of female over male mortality (MFMR=96,6).
Although this is, indeed, an unusual finding\(^7\), values of MFMR below 100,0 –when answers from women aged 20-24 years are considered– are present throughout the country, being one exception the North East Region where MFMR is 106,0\(^8\).

The of excess of female over male mortality, when considering the census data on the proportion of children dead, seems to be located mainly in urban areas where otherwise the sex difference is almost non existent. In rural areas the data indicate that mortality is always higher among boys, the mortality difference by sex, however, is small since MFMR oscillates around, say, 110%. (See Table 2).

The relative variation between urban and rural area (See third panel in Table 2) indicates that, though the former has always lower mortality risks than the latter, the difference by sex favors proportionally more the urban boys. Values form children from mothers aged 20-24 years old –which, as always said, give most reliable answers– reveal that male \(_2q_0\) in the urban area is 27% lower than in the rural area while the equivalent for females is only 17%. The similar relative variations by age of mother indicates that in a situation of better life conditions, which it would be the case for urban areas, gains in mortality are higher among boys than girls.

<table>
<thead>
<tr>
<th>(2q_0)</th>
<th>(2q_0)</th>
<th>(2q_0)</th>
<th>(2q_0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>100.4</td>
<td>93.6</td>
<td>98.3</td>
</tr>
</tbody>
</table>

*Estimated using Brass technique on surviving children

Source: IBGE Foundation, Demographic Censuses - 2000 and 2010 (micro data)

Finally, this pattern (smaller urban MFMR than rural ones and proportionally higher urban/rural differences favoring urban boys vis-à-vis girls) is present throughout the

\(^7\) Excess of female over male mortality at very younger ages has been observed, for instance, by Faveau et al (1991). The context however, as opposite to the Brazilian case, corresponds to a high and rather constant infant mortality levels.

\(^8\) Although values are not showed, they are implicit in table A2, in Annex.
Brazilian territory, as in the case of the sex ratio for population below age 10, being more frequent in the South and Southeast states. The unusual finding of excess of female over male mortality when census data on surviving children are used is consistent, in a way, with information on children's sex ratio. The source to some extent is the same once the report on children residents in the household—the necessary information to calculate the sex ratio—is probably done by the same woman that reports the number of CEB and SC. Therefore and even when this information is considered quite robust to estimate mortality levels, we use additional data to continue evaluation of the sex differentials on child mortality.

For this purpose, answers on household deaths, by sex and age, in the 12-month period prior to the census are used to calculate directly the mortality rates. Estimates of differences by sex related to IM are shown in Table 3 that includes information on geographical Regions. The value of IM is not given here due to the unreliability of this type of data to establish the mortality levels at earlier ages, notwithstanding, we assume that mistakes or misreports would not have sex biases.

<table>
<thead>
<tr>
<th>Geographical Regions</th>
<th>MFMR</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>123.1</td>
<td>119.9</td>
<td>128.7</td>
</tr>
<tr>
<td>North</td>
<td>130.3</td>
<td>125.8</td>
<td>138.2</td>
</tr>
<tr>
<td>North East</td>
<td>119.7</td>
<td>115.9</td>
<td>127.7</td>
</tr>
<tr>
<td>South</td>
<td>125.3</td>
<td>119.7</td>
<td>130.4</td>
</tr>
<tr>
<td>South East</td>
<td>122.4</td>
<td>126.1</td>
<td>111.9</td>
</tr>
<tr>
<td>Midwest</td>
<td>127.3</td>
<td>117.1</td>
<td>131.3</td>
</tr>
</tbody>
</table>

* Infant mortality is calculated using reported household deaths for population under age 1 in the 12-month period prior to the census and residents below age 1, by sex.

Table 3

On the one side, differently to the probabilities of dying from the information on surviving children, the direct estimates do not present excess of female over male mortality and highest and lowest differences are located in regions that have both, the lowest socioeconomic development. On the other side, however, the differential by sex and urban/rural areas replicates the pattern identified earlier: there are, in general, smaller mortality differences by sex in the urban area than in the rural one. The only exception is the South East, where the level of MI it is known to be among the lowest in the country, reaching values close to 10 per thousand. Additionally, knowing that

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9 A more detailed data are shown in Annex, Table A2.
10 Table A1 in Annex illustrates de socioeconomic development differences that the Brazilian Geographical Regions have.
11 See, for instance: Simoes & Monteiro, 1995; Reis et al., 2006; SEADE, 2011.
regions such as North and Northeast have customarily mortality levels above average, we note also that these differences are not related to the levels.

An additional consideration on the reliability is this type of data by geographic regions is needed. Despite the probably underreporting gap between both events (births and deaths) and between different regions—as we assume that the differences in the degree of socioeconomic development that these regions affect their data reliability—we believe that quality of data is not affected by the sex of the child alive or reported as dead over the 12 months previous period.

### 2.2 Sex differentials in child mortality estimated using vital statistics

In order to further explore the pattern of sex differentials in child mortality another source is used here: vital statistics. We use the Brazilian Health Statistics System for live births (SINASC) and deaths (SIM)\(^\text{12}\); data are for a four-year period (2008 to 2011). Table 4 shows the MI by sex and the infant MFMR by age of mother for the whole Brazil. As an indicator of the reliability that should be given to these data, it is worth to note the typical J shape by age of the mother that the data reproduce. Highest rates correspond to extreme ages of reproductive period regardless the child's sex being even higher at older ages. IM for children whose mother is 45-49 years old is 2,5 times higher than those whose mother is in their early twenties. The gap is higher in the case of girls (2,8)

<table>
<thead>
<tr>
<th>Mother's age</th>
<th>Male *</th>
<th>Female *</th>
<th>Total *</th>
<th>Infant MFMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>15,5</td>
<td>12,7</td>
<td>14,1</td>
<td>121,9</td>
</tr>
<tr>
<td>20-24</td>
<td>12,4</td>
<td>10,2</td>
<td>11,4</td>
<td>121,4</td>
</tr>
<tr>
<td>25-29</td>
<td>11,1</td>
<td>9,2</td>
<td>10,2</td>
<td>120,3</td>
</tr>
<tr>
<td>30-34</td>
<td>11,0</td>
<td>9,2</td>
<td>10,1</td>
<td>119,4</td>
</tr>
<tr>
<td>35-39</td>
<td>13,2</td>
<td>11,3</td>
<td>12,3</td>
<td>116,8</td>
</tr>
<tr>
<td>40-44</td>
<td>18,1</td>
<td>15,4</td>
<td>16,8</td>
<td>117,5</td>
</tr>
<tr>
<td>45-49</td>
<td>25,0</td>
<td>25,8</td>
<td>25,4</td>
<td>96,6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15,6</strong></td>
<td><strong>12,9</strong></td>
<td><strong>14,3</strong></td>
<td><strong>120,4</strong></td>
</tr>
</tbody>
</table>

Source: Datasus/SIM/SINASC

* Data not adjusted due to under reporting. Misreporting by mother's age on infants deaths is proportionally higher than on live births; thus, infant mortality rates by mother's age have an underestimation of around 15 to 18 per cent.

** Total includes register of children dead with unknown mother's age.

Related to the differential by sex, we note that there is a downward trend in the MFMR as the mother's age increases. It starts with an index of 122 for women aged 15-19 and, although there is a slight stall, the downward trend continues up to age 45-49 when the mortality sex difference reverses. For oldest women, the MI is higher among girls.

There are two considerations to be made in this case. Firstly, it is debatable whether the reversal of the gender gap is not the result of random variations and typical of small numbers. In fact, the volume of events involved in this age group is around 100-150 annual infant deaths for the whole country. Secondly, in opposition to the randomness, we should mention that the excess of female over male mortality at this extreme age of mothers is rather constant over the period considered.

Figure 3

Brazil, 2008-2011: Male to Female Mortality Ratio (MFMR) by age of mother

a) By Calendar year

Figure 3 displays the curve corresponding to FMMR for each calendar year considered and for the 4-year average. Regardless of the oscillations, the general impression is that the curves tend to decrease as age of mother increases. One further element against the randomness is the fact that data classified by geographic regions replicate the pattern of excess of female over male mortality at older mother's age, with the exception of the South East. The regions responsible by the downward trend by mother's age and the FMMR below 1,0 are the South and the North East. Both regions, broadly speaking have the highest and lowest socioeconomic development, respectively. They both are also known for having differences in the quality of data: coverage of vital statistics is rather complete in the South, while the opposite is true for the North East. Thus, we can not establish a relationship on excess of female over male mortality and mortality levels or socioeconomic development.

3. International historic evidence of infant mortality differentials by sex

Having found that the sex differentials by sex in child mortality in Brazil, in a context of fast mortality decline tends to minimize, it is important to check the trends and magnitudes of these differences in different contexts. In this section we present two pieces of evidence: life tables (modeled and empirical) and international vital statistics.

3.1 MFMR and life tables

Infant mortality from life tables are presented here considering, firstly, the Coale and Demeny model life tables (1966), using the West family which is frequently used to estimate mortality in Brazil and most developing countries. Excess of male over female mortality is almost universal in this life tables with the exception of the reproductive ages and at very high mortality levels. The sex differential in the probability of death among children below age 1 shows always favors females (MFMR above 1,0) (See Figure 4).

Another empirical set of life tables, the United Nations Model Life Table (United Nations, 1982) shows similar pattern of MFMR to that mentioned above (See Figure 4,b). Developing countries used in that publication for modeling –whose data were, in all cases properly evaluated– present, in general, an increase in infant MFMR as E(o) increases. What is important to emphasize here is that E(o) increases as times goes by, thus there is also a chronological sequence where increases in the MFMR seems to have each time smaller increments. This trend is evidenced by including in the comparison the statistics from Sweden with a series of a wider period of time. The Swedish data describe the trend of the infant MFMR since 1850 to 2010, when the male E(o) was 55 and 79.7 years respectively: it increases along with increases in E(o), and similarly to the trend observed in developing countries, the increase in MFMR gets smaller

increments as time goes by and mortality level declines. At some point, (around a male E(o) of 70 years) those increments become negative without experiencing, however, excess of female to male mortality.

A statistical adjust to the data set on Figure 4, b suggests the existence of a MFMR pattern associated with life expectancy at birth (see the dotted line on the same graph). The MFMR would be small when infant mortality levels are high; it would tend to increase together with the general social conditions, i.e., when mortality declines. Then, at lower mortality levels — contrary to what was established in the life tables showed here — the MFMR would decrease again as data from developed settings present (See Figure 5 that illustrates trends in Japan, England & Wales, France and Sweden). Smaller decreases in the ratio follow time in these countries when infant mortality started to show levels below 20 per thousand (as it is the case in Brazil over the 2010s).

Also note that the Japanese infant MFMR trend over this period, shows increases before falling down.

**Figure 4**

*Male to female mortality ratio (MFMR) for the probability of dying, according to male E(o)*

*a) For ages 0 to 5 in the Coale & Demeny Model Life Tables (levels 17-24)  
b) For age 0 in selected countries used in the UN Life Tables Model for developing countries and Sweden*

Source:
*a) Estimated from survival functions for ages between 0 and 4, available in Manual X (United Nations, 1983) and,  
b) United Nations, 1982: Model Life Tables for Developing Countries (United Nations publication, Sales No. E.81.XIII.7).*

It is worth to note that in all cases, infant mortality is declining and their level is currently around 5 per thousand. The current downward trend in MFMR that these
countries show indicates that at very low infant mortality levels, better life conditions seems to benefit proportionally more male children\textsuperscript{14}.

\textbf{Figure 5}

\textit{Japan, England& Wales, France and Sweden (1970-2010): Infant MFMR}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure5.png}
\caption{Japan, England& Wales, France and Sweden (1970-2010): Infant MFMR}
\end{figure}


\subsection*{3.2 MFMR and vital statistics series}

Comparison of a wide set of infant MFMR associated to IM levels by sex is made in Figure 5. Scatter plot includes vital statistics from populations with relatively reliable data for variety of periods that goes since the sixties up to later years of the 2000 decade\textsuperscript{15}; IM estimates for the five Brazilian geographic regions for the average period 2008-2011 are also displayed.

The scatter plot shows that, in general, there is a rather weak association between IM level and the MFMR regardless of sex. It also indicates, according to the solid line, that the male IM is, on average, 30\% higher than the female IM. Excess of male over female infant mortality (MFMR above 100) is the most regular situation with few opposite cases; MFMR below 100 corresponds in this cases to low IM levels (below 10 per thousand).

All together, the data show a downward trend in MFMR as IM mortality levels decrease starting from, say, 10 per thousand. The decline of MFMR as IM level goes down seems slightly more accentuated for boys thus indicating that very low IM favors less sex differentials despite of the wider dispersion. In a way, the scatter plot confirm

\textsuperscript{14} Drevenstedt et al., (2008) using a wider data set argues that reduction in sex differences in developed countries are also due to improvements in medical and technological dimensions of care.

\textsuperscript{15} Table A3 in Annex presents the countries and periods considered.
findings by Drevenstedt et al., (2008) that declines in infant mortality are correlated with rising MFMR until the level of mortality becomes relatively low.

Brazilian MFMR for year 2010, is located below the average line regardless of the IM level for any sex; values as seen, are around 1.2.

4. Discussion

The evidence showed for Brazil in the previous lines indicates that in the current context of relatively fast IM decline, reaching levels below, say, 25 per thousand, mortality sex differences at early life are smaller than in modeled estimates or historic data.

As a way of summing up, the evidence is given by:

a) Sex ratio trends for the population under 10 years old –considering that historic trends signal that mortality risks vis-à-vis age are, in general higher among male than female– does not have a decreasing trend by age as expected:
- At any given period SR does not decrease by age; furthermore, in the rural area increases in SR are more accentuated according to increases in age.

- Across time, the more recent the census, the higher the SR at any given age.

- The pattern is present over four decades in the case of Brazil; data on SR from other Latin American countries present similar trend.

b) Recent Brazilian census data (2000 and 2010) signal that in the process of declining infant and child mortality –when proportion of children dead from mothers at any given age halved– gains were proportionally higher among boys. When urban and rural areas are considered, data indicates that better life conditions are associated to higher gains in male child mortality than in female thus excess of male over female mortality is smaller in urban areas. This difference is also observed in data from reported deaths in the household.

c) Vital statistics with different degree of reliability indicates that excess of male over female mortality implies an average MFMR around 1,2, pointing smaller ratios as the mother gets older. Ratios below 1,0 for mothers aged 45-49 were observed in every calendar year over a four year period.

Historic evidence indicates that a common sex differential in mortality at early years of life represented a MFMR around 1,3 regardless of mortality levels; data from developed countries point towards a trend where, while in the past, MFMR could have been, indeed around 1,3 or higher, recently and at very low levels, the ratio would tend to decrease indicating smaller differences by sex and then, pointing to minimize them.

The pattern found using Brazilian data, suggest that excess of male over female mortality is small at early years of life, with MFMR below 1,2.

Data from the five past censuses indicate that boys mortality risks are declining at a constantly higher ratios than girls thus, MFMR was probably higher in the past. As the past patterns were usually estimated using indirect methods (UN, 2011; Sawyer, 2012) more research is necessary before to conclude that the patterns identified here are a recent/new trend.

We find reasonable to say that the narrow current mortality sex differences among children in Brazil –as a representative country in developing settings– is the product of the strategies for reducing mortality levels. More research is needed to prove that biological differences (where male children are at disadvantage) are highly sensitive to both the medical-technical and epidemiological contexts. As Drevenstedt et al. (2008) find for developed settings.

Without disregarding prejudices on gender, although there are no evidence for Brazil about devaluation/revaluation of girls, research on the pattern of causes of death by sex and benefits of obstetrical practice and neonatal care among babies boys and girls can give us important insights about how much these factors are responsible for reducing the infant and child mortality and how much of these gains have benefited more the baby boys.
References


Websites visited
http://www2.datasus.gov.br/DATASUS/index.php?area=0205
www.ibge.gov.br
www.sidra.ibge.gov.br
www.un.org/esa/population/
http://unstats.un.org/unsd
http://www.mortality.org/cgi-bin/hmd/country.php?cntr=SWE&level=1
**ANNEXES (Tables and figures)**

*Table A1.*

**Brazil and Geographic Regions – Selected socioeconomic indicators (Circa 2010)**

<table>
<thead>
<tr>
<th>Region</th>
<th>Households with monthly per capita income below ½ minimum wage(*)</th>
<th>Per capita gross domestic product (US $)</th>
<th>Infant Mortality (2005-2010) (per thousand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAZIL</td>
<td>34,67</td>
<td>8,593</td>
<td>18.7</td>
</tr>
<tr>
<td>North</td>
<td>52,79</td>
<td>5,522</td>
<td>22.5</td>
</tr>
<tr>
<td>North East</td>
<td>56,10</td>
<td>4,156</td>
<td>25.1</td>
</tr>
<tr>
<td>South East</td>
<td>23,74</td>
<td>11,297</td>
<td>14.4</td>
</tr>
<tr>
<td>South</td>
<td>19,19</td>
<td>10,328</td>
<td>12.7</td>
</tr>
<tr>
<td>Midd West</td>
<td>25,92</td>
<td>10,843</td>
<td>16.8</td>
</tr>
</tbody>
</table>

(*) Per cent - One minimum wage in 2010 was around US $ 320 per month

Source: IBGE – SIDRA System and RIPSA – IDB

http://tabnet.datasus.gov.br/cgi/idb2011/matrix.htm#socio 7/28/2013 7:28 PM
Table A2.
Brazil and Geographic Regions, 2010: Proportion of children dead (D_x), probability of dying between age 0 and x (xq0) and male to female mortality ratio (MFMR) - Using Census data on surviving children.

<table>
<thead>
<tr>
<th>Mother's age group</th>
<th>Children's age group (x)</th>
<th>Brazil</th>
<th>North</th>
<th>North East</th>
<th>South East</th>
<th>South</th>
<th>Midd</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
</tr>
<tr>
<td></td>
<td>Dx q(0)</td>
<td>Dx q(0)</td>
<td>Dx q(0)</td>
<td>Dx q(0)</td>
<td>Dx q(0)</td>
<td>Dx q(0)</td>
<td>Dx q(0)</td>
<td>Dx q(0)</td>
</tr>
<tr>
<td>15-19</td>
<td>0</td>
<td>0,0167</td>
<td>0,0166</td>
<td>0,0200</td>
<td>0,0173</td>
<td>0,0159</td>
<td>0,0187</td>
<td>0,0163</td>
</tr>
<tr>
<td>20-24</td>
<td>2</td>
<td>0,0153</td>
<td>0,0163</td>
<td>0,0211</td>
<td>0,0198</td>
<td>0,0152</td>
<td>0,0163</td>
<td>0,0208</td>
</tr>
<tr>
<td>25-29</td>
<td>3</td>
<td>0,0155</td>
<td>0,0138</td>
<td>0,0237</td>
<td>0,0211</td>
<td>0,0153</td>
<td>0,0156</td>
<td>0,0232</td>
</tr>
<tr>
<td>30-34</td>
<td>5</td>
<td>0,0188</td>
<td>0,0185</td>
<td>0,0306</td>
<td>0,0289</td>
<td>0,0186</td>
<td>0,0183</td>
<td>0,0301</td>
</tr>
<tr>
<td></td>
<td>100,4</td>
<td>100,4</td>
<td>115,1</td>
<td>115,1</td>
<td>93,6</td>
<td>93,6</td>
<td>106,4</td>
<td>106,4</td>
</tr>
</tbody>
</table>

Table A3.
Selected countries and periods with relatively reliable vital statistics on infant deaths and live births

<table>
<thead>
<tr>
<th>Country</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>1985 2009</td>
</tr>
<tr>
<td>Austria</td>
<td>1967 2001</td>
</tr>
<tr>
<td>Belgian</td>
<td>1962 1997</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>1971 2009</td>
</tr>
<tr>
<td>Chile</td>
<td>1982 2008</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>2009 2010</td>
</tr>
<tr>
<td>Croatia</td>
<td>2004 1982</td>
</tr>
<tr>
<td>Cuba</td>
<td>1975 2005</td>
</tr>
<tr>
<td>Denmark</td>
<td>1961 2000</td>
</tr>
<tr>
<td>France</td>
<td>1962 1994</td>
</tr>
<tr>
<td>Germany</td>
<td>1971 1994</td>
</tr>
<tr>
<td>Greece</td>
<td>1971 2000</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1960 1998</td>
</tr>
<tr>
<td>Portugal</td>
<td>1996 1995</td>
</tr>
<tr>
<td>Spain</td>
<td>1975 1996</td>
</tr>
<tr>
<td>United Kingdom &amp; North Ireland</td>
<td>1982 1998</td>
</tr>
<tr>
<td>Uruguay</td>
<td>1986 2002</td>
</tr>
</tbody>
</table>

Source: IBGE- Microdata 2010 Census

**Figure A1.**

*Latin America and the Caribbean, 1950-2015: Infant Mortality*

![Graph showing infant mortality trends in Latin America and the Caribbean from 1950 to 2015. The graph includes data for Lat. Amer. & Caribbean, Caribbean, Central America, South America, and Brazil.](image-url)

Figure A-2:
Brazil - Geographic Regions (total, urban and rural) - 1970-2010: Sex ratio by age (0 to 9 years old)

Figure A3. Costa Rica and Argentina, selected censuses years: Sex ratio by age*, (Per cent)

Source: IPUMS tables

* Sex ratio is calculated for ages 0-1, 2-3, etc. in order to avoid variations from poor data quality and small numbers.

Figure A4.

Location of the Brazilian Territory

Source: http://mapsof.net/uploads/static-maps/where_is_brazil_located.png 7/28/2013 7:19 PM