A decomposition of changing child sex ratios in India into fertility and mortality components

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Abstract:

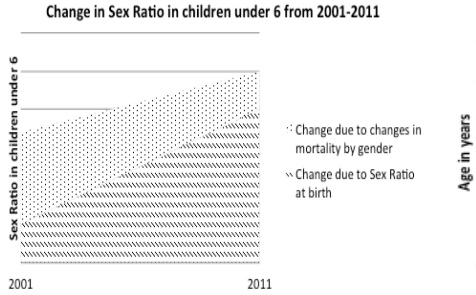
Although child sex ratios in India showed evidence of decline in the 2011 Indian census (fewer girls than boys), some districts which historically have been very skewed showed signs of improvement. This analysis decomposes child sex ratios in 2001 and 2011 into fertility and mortality components, and then explores the trends over time. The goal is to see if improvements are due to reduction in sex selection abortion or improvements female child mortality rates. Initial analysis shows that, assuming static birth rates by gender (no change in sex selective abortion), suggests that in most states of India females have had greater improvements in mortality rates. The next steps explore the contribution due to sex ratios at birth, and then compare the trends in mortality to other countries, age groups and model life tables to test how much of the improvement is due to expected declines in mortality with development.

Introduction:

India has been faced with an overall decline in the child sex ratio in recent decades (the child sex ratio is measured as the number of girls under 5 divided by the number of boys under 5).[1] This is due to a combination of son preference, access to sex selective technologies and excess female-child mortality. [2, 3] Therefore, part of the skewed child sex ratios comes from a skewed sex ratio at birth (sex selective abortion), and part from excess female mortality under age five. [4, 5] Although for the country overall child sex ratios are falling, recent analysis of the 2011 census by Diamond-Smith and Bishai (2013) suggests that the states and districts that have historically had the lowest child sex ratios are beginning to show some signs of improvement (their child sex ratios are becoming less skewed, or slowing in their rate of decline).[6] This suggests that perhaps people are beginning to change their behavior to discriminate against girl children less. It is important to understand this phenomenon more fully, especially to determine if the improvement is due to less sex selective abortion or to less excess female child mortality. The aim of this analysis is to decompose the changes in child sex ratios in the districts and states of India that have shown evidence of improvement or slowing to understand if the change is due to a reduction in sex selective abortion or excess female mortality. Decomposition analyses allow us to separate the change in sex ratio over time into the various components that make up that change. To do this, we combined data on births, and infant and child mortality by sex for the cohorts that make up the children under 5 who are alive in the 2001 and 2011 censuses, and see how the trends change between the two cohorts of children.

Data and Methods:

As can be seen in Fig 1, the total change in sex ratio in children between 2001 and 2011 is made up of changes in the sex ratio at birth and changes in differential mortality by gender. It is possible, as shown in Fig 1, that the relative importance of the two components might change over time.



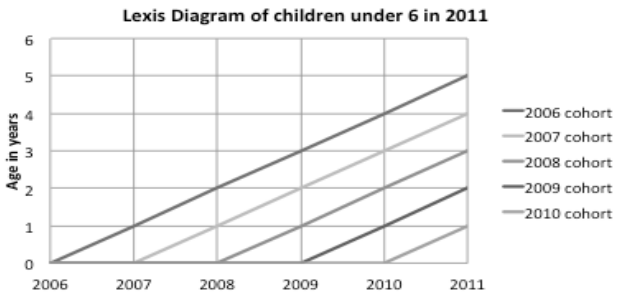


Fig 1: Graph of Hypothetical Decomposition; Fig 2: Lexis Diagram

Figure 2 shows the Lexis diagram of the five groups of children that can contribute to those under six years old in the 2011 census. If we take the first cohort, those born in 2006 (from Jan 1, 2006-Dec 31, 2006), and they progress over time to being age five in 2011. Of course, not all of these babies born in 2006 will survive to 2011, so we have to

allow for mortality. If we start by just looking at the females (F) who are alive in 2011 and are in the oldest age group (4-5 years old), denoted ${}_1F_{4(2006)}$, those are made up of the births of females in 2006, denoted $B_{(F,\,2006)}$, multiplied by the Probability of surviving from 0-1 years for females born in 2006, denoted ${}_1p_{0(F,\,2006)}$, multiplied by the probability of surviving from 1-4 years for females born in 2006, denoted ${}_3p_{1(F,\,2006)}$, and multiplied by the female person-years lived to 1/1/2011 among those born in 2006, divided by the female survivors to age 4 among those born in 2006, denoted $\frac{{}_1L_{4(F,2006)}}{l_{4(F,2006)}}$.

$$ {}_1F_{4(2006)} = B_{(F,2006)} * {}_1p_{0(F,2006)} * {}_3p_{1(F,2006)} * \frac{{}_1L_{4(F,2006)}}{l_{4(F,2006)}} \quad (1) $$

Now, if we include the information about boys (M), we can get ratios. The equation now becomes:

$$ \frac{{}_5F_{0(2006)}}{{}_5M_{0(2006)}} = \frac{B_{(F,2006)}}{B_{(M,2006)}} * \frac{{}_1p_{0(F,2006)}}{{}_1p_{0(M,2006)}} * \frac{{}_3p_{1(F,2006)}}{{}_3p_{1(M,2006)}} * \frac{\frac{{}_1L_{4(F,2006)}}{l_{4(F,2006)}}}{\frac{{}_1L_{4(M,2006)}}{l_{4(M,2006)}}} \quad (2) $$

All of the cohorts that make up all of the children under 6 in 2011 (those born in 2006, 2007, 2008, 2009 and 2010) must be summed together. A shortened version of the equation would be Equation 3, where t is the year (eg 2006, 2007, etc):

$$ \frac{{}_5F_{0(2006-2010)}}{{}_5M_{0(2006-2010)}} = \sum_{2006}^{2006+4} \frac{B_{(F,t)}}{B_{(M,t)}} * \frac{{}_1p_{0(F,t)}}{{}_1p_{0(M,t)}} * \frac{{}_3p_{1(F,t)}}{{}_3p_{1(M,t)}} * \frac{\frac{{}_1L_{4(F,t)}}{l_{4(F,t)}}}{\frac{{}_1L_{4(M,t)}}{l_{4(M,t)}}} \quad (3) $$

To make the comparison, we will then do this same exercise but for the 2001 census to calculate the contribution to the sex ratio of mortality and fertility for children born between 1996-2001, who make up the children under 6 in the 2001 census. With the same decomposition information for the 2001 and 2011 census, we can compare the contribution to the sex ratio at each time point, and see if there was a change in the contribution due to mortality versus fertility between the two censuses.

The Sample Registration System (SRS) collects data from a sub-set of the population every year and calculates sex ratios at birth and estimates of birth cohort size by sex. The SRS also collects data and produces rates for infant and child mortality annually by state, therefore, we can use this data to separate out changes in mortality trends. Table 1 shows female life table values that will be used in the calculations for 1996-2000 and 2006-2010 (same data for males not shown).

Preliminary findings:

To begin, we calculated the amount of change in the child sex ratio that was due to changes in sex and age specific mortality between the two time periods alone. To do this,

we applied the life table probabilities and values from Table 1 to a hypothetical cohort of 100,000 boys and 100,000 girls born (equal number of births by sex). Fig 3 shows the ratio of estimated survivors in 2011/2001 for females and males by state. This gives an estimate of how much improvement there has been in the past 10 years in child mortality rates by sex. A higher ratio means that there were more survivors in the later time period, in other words, child mortality rates went down. In most states females have had greater improvements in mortality rates than males in the 10 years between 2011 and 2001. The exceptions are Assam, Himachal Pradesh and Kerala (where the rates of improvement for both sexes are very low most likely because mortality rates are already fairly low in this state, so there is less room for improvement). This preliminary analysis suggests that perhaps much of the improvement in child sex ratios is due to improvements in child mortality rather than reductions in sex selective abortion.

Since we expect that the trend in the ratio of mortality by gender will shift with development, regardless of changes in son preference and expression of that preference, it is essential to compare any trend in mortality differentials over time in this analysis to a reference country (that does not have evidence of strong gender preference) during the time that country experienced the same level of child mortality change. This will help us see if any improvement in child mortality is far from an expected trend. We will also compare the trend seen in India to model life tables. This will help to correct the estimation for secular changes.

The next steps are to add in information about sex ratios at birth, to understand the contribution to the child sex ratio from sex selective abortion, in combination with excess female mortality. We will explore how these two contribute shifted over time, and if there was any specific time period or states that have unexpected patterns.

Table 1: Female infant and child probability of survival, survivors at age 4, probability of survival from age 4-5 and survivors at age 5, assuming equal sized birth cohorts, from 1996-2000 and 2006-2010 (data not shown for males)

	1996-2000					**2006-2010**				
	1p0	4p1	l4	4L1	Survivors at age 5	1p0	4p1	l4	4L1	Survivors at age 5
Andhra Pradesh	0.94	0.98	94206	371673	363,767	0.95	0.99	94889	378018	375625
Assam	0.92	0.97	92222	360626	348,214	0.94	0.97	94121	369949	359960
Bihar	0.92	0.96	91588	356966	342,970	0.95	0.97	95375	374836	364569
Gujarat	0.93	0.97	93156	365910	355,717	0.95	0.98	94531	374226	368212
Haryana	0.92	0.97	92153	360232	347,653	0.94	0.99	94062	372844	367598
Himachal Pradesh	0.94	0.98	94366	372537	364,961	0.96	0.99	95685	380764	377672
Karnataka	0.94	0.98	94360	372505	364,917	0.96	0.99	95559	380308	377296
Kerala	0.99	1.00	98944	395232	394,361	0.99	1.00	98741	394411	393528
Madhya Pradesh	0.90	0.95	90116	348240	330,337	0.93	0.97	92598	363974	354260
Maharashtra	0.95	0.98	95241	377175	371,298	0.97	0.99	97092	386505	383568
Orissa	0.91	0.96	91344	355541	340,918	0.93	0.98	93145	367201	359009

Punjab	0.94	0.98	94427	372865	365,414	0.96	0.99	95784	380011	375143
Rajasthan	0.90	0.95	90314	349433	332,072	0.93	0.97	92918	365619	356427
Tamil Nadu	0.95	0.99	95493	378484	373,062	0.97	1.00	96943	386602	384750
Uttra Pradesh	0.90	0.95	90143	348403	330,574	0.93	0.97	92703	363097	351449
West Bengal	0.94	0.98	93886	369938	361,360	0.97	0.99	96606	384757	382137

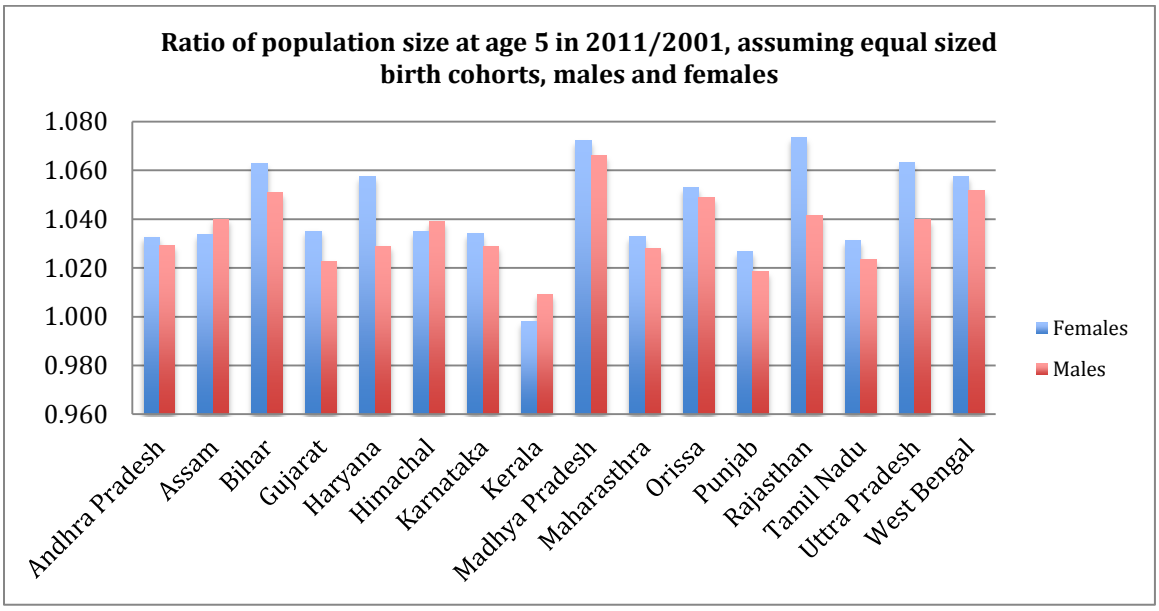


Fig 3: Ratio of population size at age 5 in 2011/2001, assuming equal sized birth cohorts, males and females

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