Does the prenatal factor or the postnatal factor contribute more to changes in the child sex ratio in India? An investigation in the context of fertility and mortality transition

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Abstract

There has been a drastic decline in the child sex ratio (number of females per 1000 males between ages 0 and 4) in India and many of its states. This study aimed to examine if prenatal factors, such as change in sex ratio at birth, or postnatal factors, such as change in relative mortality of females and males, contribute to this more by analysing the dynamics of the child sex ratio. Changes in the child sex ratio during 2001–2011 were decomposed into a 'fertility' component attributable to prenatal sex selection and a 'mortality' component attributable to sex differentials in postnatal survival at the country as well as the state level. Between the prenatal factor and the postnatal factor, the contribution of the latter to the declining child sex ratio has been greater than the former in India as a whole and in most of the states. By focusing on both prenatal and postnatal factors, the imbalance in the child sex ratio in the country can be reduced to a large extent.

Keywords: Child sex ratio; Prenatal factor; Postnatal factor

Introduction

India has experienced a significant decline in fertility and in the child sex ratio (CSR: number of females per 1000 males between ages 0 and 4) in recent years (Guillot, 2002). On the other hand, with remarkable improvement in child mortality, excess female mortality has reduced over time. Recent studies have found that the declines in the CSR and excess female mortality were very high when prenatal sex selection emerged as a dominant factor (Kashyap, 2018). Since sex-selective abortions were rampant during the 1990s in India, a significant decline in the population sex ratio was recorded in the 2001 and 2011 censuses (Guillot, 2002). Improvements in female relative mortality with respect to male started to have a decreasing effect on the population sex ratio only after 1991. The declining under-five mortality rate for both sexes has certainly reduced absolute excess girl child deaths (Ram & Ram, 2018). However, based on a systematic assessment by Alkema and colleagues (Alkema *et al.,* 2014), India is still identified as having the highest excess female under-5 mortality rate in the year 2012, and the relative disparity between the estimated and the expected female under-five mortality rates worsened between 1990 and 2012. Furthermore, neither fertility nor mortality decline is uniform across the country, with southern India, urban areas and higher socioeconomic groups having lower fertility and mortality than their counterparts (Arokiasamy & Goli, 2012). Given the heterogeneous nature of Indian demography across states, it is imperative to look into prenatal and postnatal factors effect on the change in CSR at the state level.

This study attempts to shed light on the contribution of prenatal and postnatal factors to the declining CSR in India between two consecutives censuses, 2001 and 2011. It assesses the geographical variations in sex-selective abortion as the prenatal factor on the one hand, and gender differentials in mortality during infancy and childhood as the postnatal factor on the other hand. By taking state as a unit of analysis, the inter-state variations demonstrated by the study will have great value for demographers, social scientists and policymakers. Prenatal sex selection is a relevant issue for at least two reasons. First, it is widely argued that son preference is slowing the transition to lower fertility in India. This is because women continue to bear children until their desired number of sons is reached. Additionally, son preference implies gender discrimination, which is visible in a broad range of sex-selective behaviours (Rosenzweig & Schultz, 1982; Behrman, 1988; Das Gupta & Mari Bhat, 1997; Basu, 1999; Sengupta & Agree, 2002; Pande, 2003; Borooah, 2004; Srinivasan, 2005; Pande & Astone, 2007; Jensen & Oster, 2009). These studies proved that sex-selective abortion and infanticide causing distortions in the sex ratio at birth in the Indian context. Also, they claim that low health care seeking behaviour and poorer nutritional feeding practices exert additional mortality risks on girls reducing the survival chances for female children in the early years of life in India.

For the postnatal mechanisms, the levels of excess female mortality are likely to vary at different stages of the demographic transition. As the transition proceeds and parents benefit from greater access to contraception, postnatal excess mortality for girls may emerge indirectly from the fertility effects of son preference (Kashyap, 2018). In this mechanism, while within-family differences for girls and boys may be small, the indirect effects of the fewer resources *per capita* available in larger families (into which girls are more likely to be born) compared with smaller families result in higher aggregate-level mortality risks for girls (Rosenblum, 2013; Barcellos *et al.,* 2014; Kashyap, 2018).

Methods

Data source

To decompose the sex ratio by age and sex, data from two consecutive censuses of India conducted in 2001 and 2011 were used (Office of the Registrar General (ORG) & Census Commissioner, 2001, 2011). Sex ratio at birth (SRB) was obtained from the Sample Registration System for the periods 1996–2001 and 2006–2011 for India as a whole and the larger states. Changes in the SRB were examined in the age groups 0–4, 5–9 and 10–14 using two consecutive censuses, 2001 and 2011. These three age groups can potentially reflect both the prenatal and postnatal effects on the CSR that occurred during 1986–2011. The SRS held under the guidance of the office of the Registrar General and Census Commissioner of India is a primary and continuous source of data on SRB from the year 1999 onwards. Therefore, the SRB required for 1986–1991 prior to 1999 was estimated using information given in the 1991census on children ever born among women in the age group 20–29. The age groups, census year and period to which the required sex ratio at birth effects correspond are given in Table 1.

Analysis was conducted for sixteen major states and for India as a whole. The included states were Punjab, Haryana and Rajasthan (from the northern region); Uttar Pradesh and Madhya Pradesh (from the central region); West Bengal, Odisha and Bihar (from the eastern region); Gujarat and Maharashtra (from the western region); Andhra Pradesh, Karnataka, Kerala and Tamil Nadu (from the southern region); and two other states, Himachal Pradesh and Assam.

Decomposition method for estimating changes in child sex ratio

Decomposition of the changes in the CSR in India between 2001 and 2011 was done using the method described below.

Let $P^{m}_{x,2001}$be the male population in age group *x* to *x*+5 years in the 2001 census, and let $P^{f}_{x,2001}$be the corresponding female population. Let the equivalent male and female populations in the 2011 census be $P^{m}_{x,2011}$and $P^{f}_{x,2011}$. Let the sex ratio at birth (females per male) in the period *x* to *x*+5 years before the relevant census be $S_{x,2001}$ and $S_{x,2011}$. Then it can be said that (ignoring migration and differential omission rates in the censuses):

$$\frac{P^{f}_{x,2001}}{P^{m}_{x,2001}} = S_{x,2001} * \{ \frac{\frac{{}_5L^{f}_0}{5l^{f}_0}.\frac{{}_5L^{f}_5}{{}_5L^{f}_5}\cdots\frac{{}_5L^{f}_x}{{}_5L^{f}_{x-5}}}{\frac{{}_5L^{m}_0}{5l^{m}_0}.\frac{{}_5L^{m}_5}{{}_5L^{m}_5}\cdots\frac{{}_5L^{m}_x}{5L^{m}_{x-5}}} \} = S_{x,2001} * \frac{{}_5L^{f}_x}{{}_5L^{m}_x} = S_{x,2001} * M_x$$

where l^{f}_0 and l^{m}_0 are the radices of the male and female life-tables, which are assumed to be equal; ${}_5L^{m}_x$and ${}_5L^{f}_x$ are the stationary populations aged *x* to *x*+5 years from the male and female life-tables, respectively (where, for the life-table quantities, the subscript 2001 denoting year is suppressed for simplicity). Henceforth, throughout this paper, the term in the above equation $\left\{\frac{\frac{{}_5L^{f}_0}{5l^{f}_0}.\frac{{}_5L^{f}_5}{{}_5L^{f}_5}\cdots\frac{{}_5L^{f}_x}{{}_5L^{f}_{x-5}}}{\frac{{}_5L^{m}_0}{5l^{m}_0}.\frac{{}_5L^{m}_5}{{}_5L^{m}_5}\cdots\frac{{}_5L^{m}_x}{5L^{m}_{x-5}}}\right\}$ is solved to $\frac{\frac{{}_5L^{f}_x}{5l^{f}_0}}{\frac{{}_5L^{m}_x}{5l^{m}_0}} = \frac{{}_5L^{f}_x}{{}_5L^{m}_x}$ and will be referred as M_x (the relative female mortality with respect to male mortality). Since the analysis deals with the population under the age of 15 years, *x* is assumed to be 0,5 and 10.

The quantity $S_{x,2001}$ measures the impact of prenatal effects on CSR and is easy to compute, and the quantity M_x, which measures the impact of postnatal effects on CSR, is complicated to compute. However, in order to achieve the study objective, it is not necessary to calculate M_x, but the ratio of $({}^{5}L^{f}_x/{}_5L^{m}_x)$ for one relevant time period to the other from the respective life-tables can be calculated directly for the selected age group.

Reintroducing the subscript 2001 for the postnatal effects, the sex ratio can be obtained from:

$$\frac{P^{f}_{x,2001}}{P^{m}_{x,2001}} = S_{x,2001}M_{x,2001}$$

Similarly, for the 2011 census:

$$\frac{P^{f}_{x,2011}}{P^{m}_{x,2011}} = S_{x,2011}M_{x,2011}$$

The change in the population sex ratio can be expressed either as a difference:

$$\frac{P^{f}_{x,2011}}{P^{m}_{x,2011}} - \frac{P^{f}_{x,2001}}{P^{m}_{x,2001}} = S_{x,2011}M_{x,2011} - S_{x,2001}M_{x,2001},$$

which is not easily decomposable into prenatal and postnatal factors, or as a ratio:

$$\left\{\frac{\frac{P^{f}_{x,2011}}{P^{m}_{x,2011}}}{\frac{P^{f}_{x,2001}}{P^{m}_{x,2001}}}\right\} = \left\{\frac{S_{x,2011}}{S_{x,2001}}\right\}.\left\{\frac{M_{x,2011}}{M_{x,2001}}\right\},$$

which is easily decomposable. With the help of this equation above, changes in the CSR can be decomposed in the form of changing sex ratio at births (SRBs) and a mortality component between the two censuses. A table comparing the left-hand term of the equation (changes in CSR), the first term of the right-hand-side of the equation (changes in SRB) and the second term of the right-hand-side of the equation (changes in relative mortality of females and males) for each state can answer the question raised in the study. For a particular age group, the first term on the right-hand side holding a value of less than 1 for a given state will suggest that prenatal factors were responsible for reducing CSR in that state. A similar interpretation holds when the second term turns out to be less than 1, which implies that postnatal factors were responsible for reducing CSR for the particular age group in a given state.

Results

At the country level, for a 10-point decline in CSR (from 934 females per 1000 males to 924 females per 1000 males; see Table 2), the prenatal factor contributed to a decline of 7 points per 1000, while the postnatal factor to a decline of 3 points per 1000 (Table 3). Table 2 shows that during the period 2001–2011, the highest decline among the age group 0–4 was registered in one southern state (Andhra Pradesh, 23), one northern state (Rajasthan, 21), one western state (Maharashtra, 18) and three eastern states (West Bengal, 7; Odisha, 14; and Bihar, 16). The change in CSR in the worst-affected state, i.e. Andhra Pradesh is attributed to the change in the SRB (prenatal factor). While in the second worst-affected state, i.e. Rajasthan, the change in relative mortality (postnatal factor) explains the change in the child sex ratio. Nine states have experienced a reduction in child sex ratio as evident from the ratio being less than 1.00. The postnatal factor primarily explains the decline in the CSR in the majority of Indian states, as evident from the changes in relative mortality estimates shown in the last column of Table 3. However, in some of these states, the prenatal factor also contributed significantly more than the postnatal factor to increases in the masculinity of the CSR, as shown in Table 3. On the other hand, the change in the prenatal factor explains the increase in the child sex ratio in Kerala, Himachal Pradesh and Haryana.

For the age group 5–9 years, changes in the SRB, i.e. prenatal factors, between the 2001 and 2011 censuses, explain the reduction in child sex ratio at the India level (Table 4). Table 2 shows that large CSR distortions are observed in the states of Maharashtra (32) and Gujarat (21) from the western region, Karnataka (20) from the southern region, Madhya Pradesh (15) and Uttar Pradesh (32) from the central region and Rajasthan (14) from the northern region. Of these six states, in Maharashtra and Karnataka both prenatal and postnatal factors contributed to a decrease in the child sex ratio in the age group 5–9 years between the two censuses. However, only prenatal factors were responsible for the deterioration in the sex ratio for children aged 5–9 years in the remaining four states. Only three states (Bihar, Odisha and West Bengal) had a higher child sex ratio in 2011 as compared with 2001 (see Table 4: column 2 estimates lie above 1.00). However, only postnatal factors explain this increase in Bihar and Odisha, whereas both prenatal and postnatal factors in West Bengal. Punjab and Haryana estimates show that prenatal factors contributed the highest in deterioration in CSR in the age group 5–9 years, which could not be compensated by improvement in female mortality relative to that of their male counterparts in these two states.

For the age group of 10–14 years, the majority of states and overall India experienced an increase in the child sex ratio during 2001–2011 (Table 5), which is attributed to the increase in female and male mortality ratio (postnatal factor). In Punjab (72) and Haryana (58) states from the northern region, huge child sex ratio (number of females per 1000 males) distortions were noted, as shown in Table 2. Table 5 shows that the postnatal factor (excess female deaths) contributed significantly more than the missing female births resulting from prenatal sex-selection to increases in the masculinity of CSRs (10–14 years) in these two states. On the other hand, in the states of Gujarat and Maharashtra in the western region and Karnataka in the southern region, prenatal factors contributed significantly to reducing CSR (10–14 years). Tamil Nadu in the south is a unique state where only postnatal factors were responsible for distortion in CSR (10–14 years).

Discussion

The findings of this study highlight several issues that have immediate policy implications. The aim of the study was to estimate the contribution of prenatal and postnatal factors to the declining child sex ratio in India and major states in the context of fertility and mortality transition. The findings suggest that both prenatal and postnatal factors have contributed to the decline in the child sex ratio. A significant decline in the population sex ratio due to sex-selective abortions was recorded in the 2001 and 2011 censuses (Guillot, 2002), which explains the role of the prenatal factor in the CSR distortions. However, the present analysis found that the role of postnatal factors was more prominent than that of prenatal factors in a majority of Indian states and in the country as whole in the age group 0–4 years.

Jha *et al.* (2011) showed that the 170% increase in selective female abortions from the 2000s to the 2010s was slower than the 260% increase from the 1990s to the 2000s. However, in the southern states of Andhra Pradesh and Karnataka and western state of Maharashtra, prenatal factors have contributed significantly to the decline in the CSR. A recent study by Chao *et al.* (2020) showed that the cumulative number of missing female births (CMFB) during 2017–2030 is projected to be 0.7 million in Maharashtra and 0.4 million in Andhra Pradesh. The postnatal factor (sex differential in infant and child mortality) affects the CSR to a large extent in several states and in India overall. The level of mortality is very high after the birth of a child in the very first week due to various endogenous and exogenous factors (Buvinic *et al.,* 2007). However, after this mortality levels should reduce with an increase in age and this is not uniformly reducing among male and female children in India. The ratio of male to female under-5 mortality rate for India in 2012 was estimated to be 0.92, the lowest among all the 195 countries in the world, as shown in the study by Alkema *et al.* (2014). Under-five mortality, a critical indicator of the Sustainable Development Goals, had declined in Uttar Pradesh, Bihar, Rajasthan and Madhya Pradesh in recent years, but the gender gap in mortality has remained almost the same (Ram & Ram, 2018).

It can also be argued that omission or misreporting could be responsible for the distortions in the CSR in India. However, compared with males, the number of females in India omitted/misreported was very high until the year 1991. After that the scenario changed, with the male undercount becoming higher (23.2 per 1000) than the female undercount (22.8 per 1000) in the 2011 census (ORG & Census Commissioner, 2001). The undercount of females aged 0–4 and 5–9 years has not been very different from that of males, and hence can't be the reason for the decline in the CSR. Post-enumeration results show that in the 2001 census the female undercount in the age group 0–4 was 32.7 per 1000, whereas for the males in the same age group the undercount was 31.5 per 1000 (ORG & Census Commissioner, 2001). In the age group 5–9, the female undercount was 23.5 per 1000, and the male undercount was 21.8 per 1000 in the 2001 census (ORG & Census Commissioner, 2001). There were no significant sex differentials in the omission rates in the country in the 2011 census, so this cannot be responsible for the decline in the CSR. The construction of the CSR by state may be affected by internal migration, but no reliable data exist for this (Guillot, 2002). No evidence has been found for female-selective out-migration or male-selective in-migration of any magnitude, especially among children, which can affect the sex ratio (Premi, 1991). So, in this analysis, migration and omission were not considered.

Sex selection is a serious cause of concern in India. Also, there is an excess incidence of female deaths during the postnatal period at young ages, especially below the age of 5 years, in many of the Indian states. Focusing on both prenatal and postnatal factors can capture the large imbalance in the CSR in the states.

Previous study conducted by UNFPA (2015) shows that the large proportion of girls are missing in India, which is also evident from this paper. Further research is needed to inform the development of policy actions to prevent sex-selective abortions and prevent the child sex ratio from becoming more skewed in India. Previous studies have shown that a serious effort towards improving the sex ratio at birth, and the child sex ratio, is being made at different levels and has been effective to a certain extent. However, effective and uniform implementation across the states and regions of India is still lacking, and this is needed if a balanced child sex ratio is to be attained.

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Table 1. Age groups, census year and period to which the required sex ratio at birth effects correspond

Census year	Age group	SRB needed for the years
2001	0–4	1996–2001
	5–9	1991–1996
	10–14	1986–1991
2011	0–4	2006–2011
	5–9	2001–2006
	10–14	1996–2001

Table 2. Decline in CSR (females per 1000 males) for three initial age groups in all India and states between 2001 and 2011

	Decline in CSR from 2001 to 2011 (females per 1000 males)
0–4 years	
India	10
Andhra Pradesh	23
Bihar	16
Madhya Pradesh	10
Maharashtra	18
Odisha	14
Rajasthan	21
Tamil Nadu	1
Uttar Pradesh	18
West Bengal	7
5–9 years	
India	9
Gujarat	21
Haryana	14
Karnataka	20
Kerala	3
Madhya Pradesh	15
Maharashtra	32
Punjab	2
Rajasthan	14
Tamil Nadu	1
Uttar Pradesh	32
10–14 years	
Gujarat	9
Haryana	58
Karnataka	10
Maharashtra	11
Punjab	72
Tamil Nadu	11

Table 3. Changes in child sex ratio (0–4 years) explained by the prenatal and postnatal factors in India and major states

States	Change in population sex ratio (f/m)	Change in SRB (fertility) (f/m)	Change in relative mortality of females and males (mortality) (f/m)
India	0.99	1.02	0.97
Andhra Pradesh	0.98	0.97	1.01
Assam	0.99	0.98	1.02
Bihar	0.98	1.05	0.94
Gujarat	1.01	1.08	0.94
Haryana	1.03	1.07	0.97
Himachal Pradesh	1.03	1.14	0.91
Karnataka	1.01	1.00	1.01
Kerala	1.01	1.06	0.95
Madhya Pradesh	0.99	1.00	0.99
Maharashtra	0.98	1.00	0.98
Odisha	0.99	1.00	0.98
Punjab	1.08	1.11	0.97
Rajasthan	0.98	1.00	0.97
Tamil Nadu	1.00	1.00	1.00
Uttar Pradesh	0.98	1.01	0.97
West Bengal	0.99	1.00	1.00

Table 4. Changes in child sex ratio (5–9 years) explained by the prenatal and postnatal factors in India and major states

States	Change in population sex ratio (f/m)	Change in sex ratio of births (fertility) (f/m)	Change in relative mortality of females and males (mortality) (f/m)
India	0.99	0.96	1.03
Andhra Pradesh	0.977	0.99	0.98
Assam	1.00	NA	NA
Bihar	1.02	0.97	1.06
Gujarat	0.98	0.92	1.07
Haryana	0.98	0.90	1.09
Himachal Pradesh	0.98	NA	NA
Karnataka	0.98	0.99	0.98
Kerala	0.997	0.96	1.04
Madhya Pradesh	0.98	0.96	1.02
Maharashtra	0.96	0.98	0.99
Odisha	1.00	0.97	1.03
Punjab	1.00	0.87	1.14
Rajasthan	0.99	0.98	1.01
Tamil Nadu	1.00	0.98	1.02
Uttar Pradesh	0.997	0.95	1.05
West Bengal	1.00	1.00	1.00

NA: for 1991 census data not available.

Table 5. Changes in child sex ratio (10–14 years) explained by the prenatal and postnatal factors in India and major states

States	Change in population sex ratio (f/m)	Change in sex ratio of births (fertility) (f/m)	Change in relative mortality of females and males (mortality) (f/m)
India	1.01	0.97	1.04
Andhra Pradesh	1.01	0.97	1.04
Assam	1.01	NA	NA
Bihar	1.06	0.98	1.08
Gujarat	0.99	0.97	1.02
Haryana	0.93	0.97	0.96
Himachal Pradesh	0.94	NA	NA
Karnataka	0.99	0.98	1.01
Kerala	1.00	0.97	1.03
Madhya Pradesh	1.05	0.98	1.07
Maharashtra	0.99	0.96	1.03
Odisha	1.01	0.99	1.02
Punjab	0.92	0.95	0.96
Rajasthan	1.01	0.96	1.05
Tamil Nadu	0.99	1.01	0.98
Uttar Pradesh	1.03	0.97	1.06
West Bengal	1.02	0.98	1.03

NA: for 1991 census data not available