Sex Ratio at Birth in India

Recent Trends and Patterns

Purushottam M. Kulkarni

(A report prepared for the United Nations Population Fund)

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Foreword

Son preference is a deep-rooted cultural phenomenon in many countries including India, which results in discriminatory and harmful practices against women and girls. It manifests itself through prenatal and post-natal discrimination against girls in the form of gender-biased sex selection. The Sustainable Development Goals by 2030 include a target (5.1) on ending harmful practices against women and girls. For years, as part of its mandate, the United Nations Population Fund (UNFPA) has focused on this issue, guided by the International Conference on Population and Development (ICPD) Programme of Action of 1994 in Cairo. This was further reinforced at the Nairobi summit on ICPD25 last year when heads of governments, civil society and grassroots organizations committed to eliminate all forms of harmful practices.

Gender-biased sex selection is measured through sex ratio at birth, a comparison of the number of girls versus the number of boys born in a given year. This requires accurate and reliable data on sex ratio at birth to judge the extent of imbalances. In India, several sources provide this indicator, however, most often these estimates do not agree to each other. This report analyses various estimates of sex ratio at birth and attempts to arrive at the most plausible level, after applying a correction factor.

Further, this report elaborates on the severity of gender-biased sex selection by examining the pre and post-natal discrimination against girls, the estimation of number of girls missing at birth, the practice of sex-selection by birth order and the sex composition of the existing number of children, based on background characteristics and by geographical regions. The report also explores various factors associated with this phenomenon and the reasons behind such discriminatory practices.

The Government of India has enacted several laws to ban pre-natal sex detection to curb the practice of gender-biased sex selection and initiated several programmes to enhance the value of the girl child. Civil society organisations have long been actively engaged in large-scale campaigns to address son preference. Although trends of the sex ratio at birth suggest that there is a continued preference for sons in the country. One of the critical aspects of this analysis is the post-natal neglect of the girl child, which has been acknowledged in public discourse, but still needs appropriate measures to address it. I wish to thank Prof. P. M. Kulkarni for his efforts in bringing out this report.

I hope that the analysis and insights from this report, looking specifically at this harmful practice in India, will complement UNFPA's State of the World Population 2020 Report that focuses on 19 harmful practices that discriminate against women and girls. Further, I hope this report will be useful for policy makers, programme planners, academia and civil society organisations to devise evidence based strategies to address the sex ratio imbalance in the country.

Argentina Matavel Piccin
UNFPA Representative India and Country Director Bhutan

Acknowledgements

The rise in masculinity in India's sex ratio at birth has been a matter of deep concern for quite some time. In view of this, the United Nations Population Fund (UNFPA) commissioned this study to examine the current situation regarding sex ratio at birth in India, obtain estimates of missing female births and missing girls, and analyse influences of various factors on pre-natal and post–natal discrimination. The initiative for this research came from Ms. Argentina Matavel Piccin, Representative, UNFPA, India. The report has benefited on account of the support of a number of officers from UNFPA, India. Ms. Ena Singh, Assistant Representative, UNFPA, India, took keen interest in the study and provided valuable suggestions. Sanjay Kumar has been associated with the research throughout the entire course of the project. He examined the methodology, drew attention to important relevant sources of data, and gave feedback on analysis and presentation. Sanjay's contribution to the study has been invaluable. Interactions with Dhanashri Brahme and Shobhana Boyle during the conduct of the study and their comments on earlier drafts have significantly strengthened the report. Hemant Bajaj and Laetitia Jones Mukhim provided efficient administrative support.

The present work has benefited immensely from discussions with Professors Christophe Guilmoto, CEPED, Paris, Ravinder Kaur, IIT, Delhi and Mary John, Centre for Women's Development Studies, New Delhi, eminent researchers in the field.

The analysis in the report has used the unit level data from various rounds of the National Family Health Survey (NFHS) and the India Human Development Survey (IHDS). Access provided to the data files by the survey organisations, the International Institute for Population Sciences (IIPS), Mumbai and the University of Maryland and the National Council of Applied Economic Research (NCAER), New Delhi, is gratefully acknowledged.

Purushottom M. Kulkarni

List of Abbreviations

BLY	Births last year
CEB	Children ever born
CRS	Civil Registration System
EFCM	Excess female childhood mortality
GBSS	Gender biased sex selection
HMIS	Health Management Information System
IHDS	The India Human Development Survey
IIPS	International Institute for Population Sciences
MA	Moving Average
MCA	Multiple Classification Analysis
NFHS	National Family Health Survey
OBC	Other Backward Caste
ORGI	Office of the Registrar General & Census Commissioner, India
PCPNDT	Pre-Conception and Pre-Natal Diagnostic Techniques
PNDT	Pre-Natal Diagnostic Techniques
PES	Post enumeration survey
SC	Scheduled Caste
SFMS	Special Fertility and Mortality Survey
SRB	Sex ratio at birth
SRS	Sample Registration System
ST	Scheduled Tribe
UNFPA	United Nations Population Fund

Executive Summary

The sex ratio at birth (SRB) in India has become more masculine in the recent decades. The imbalance in sex ratios stems from strong son preference combined with declining fertility, and the availability of and access to sonographic scanning during pregnancy. The practice of gender biased sex selection continues even though India has enacted laws banning the use of pre-natal diagnostic techniques for sex detection. The instances of gender biased sex selection are obviously not recorded but the numbers of cases can be estimated indirectly based on the deviation of the observed SRB from the natural level. To this end, this study first examined data on India's SRB from various sources, identified the most plausible estimates, and then used these to estimate the numbers of missing female births. Further, the study estimates the number of missing girls based on the 2011 census enumeration and presents the decomposition of the missing numbers by two factors, pre-natal discrimination (sex selection at birth) and post-natal discrimination (excess female childhood mortality). For the five-year period beyond the 2011 census, the study estimates gender biased sex selection and excess deaths of girls below age five. The study goes a step further and presents variations in the SRB by the stage of family building, that is, at different birth orders and by the sex composition of previous births, up to the third order. In its analysis, the study examines, socioeconomic and spatial differentials in the SRB at various stages of family building and assesses the net influences of various factors on the probability of a male birth. Finally, the study looks at recent evidence on reasons for son preference and, in particular, on the value accorded to sons vis-à-vis daughters. The main results are presented below.

The SRB in India is clearly more masculine than the natural level. In the absence of sex selection the SRB is around 105 male births per 100 female births or around 950 female births per 1000 male births whereas in India the number of female births per 1000 male births ratio has been much below 950 in the recent decades. Estimates of the SRB are available from various sources, and an assessment of these revealed that the census based indirect estimate obtained by reverse survival is the most plausible one. At the national level, this was 923 female births per 1000 male births for the period 2004-2011. The sample registration system (SRS) estimate of the SRB for this period is 903 and seems to be an underestimate (when measured in terms of females per 1000 males) by about two percent at the national level and needs to be corrected; the correction factor varies somewhat for states. The SRB has been fluctuating in the range 900 to 930 female births per 1000 male births since 2000 for India with no clear trend.

The regional pattern in the SRB is well recognized. States in the northern-western region show much more masculine SRB than in the other regions; some states in the central region also show low ratios but not to the levels of the northern-western regions. The eastern, northeastern, and southern regions generally show ratios near natural. In Punjab, Jammu and Kashmir, and Himachal Pradesh the SRB seems to have risen but is still lower than the natural level.

It is estimated that close to 400 thousand female births are missed in India annually as a result of gender biased sex selection, amounting to about three percent of female births. The degree (number of female births missed as percent of female births occurred) is high in most states in the northern and western regions, moderate in Uttar Pradesh, Himachal Pradesh and Madhya Pradesh, and low or negligible in most states in the eastern and southern regions.

At the 2011 census enumeration, about four million girls of ages 0-6 may be considered to have been missing; 2.5 million on account of sex selection (pre-natal discrimination) and 1.5 million due to excess female mortality (post-natal discrimination). This situation has persisted beyond 2011 as well. Further, while pre-natal discrimination is concentrated in the northern and western regions, post-natal - discrimination is common across the country;

the southern region and a few other states show relatively low levels but the regional differences in post-natal discrimination are not as wide as in pre-natal discrimination.

At higher birth orders and among those who have no son, the SRB is very highly masculine in the northern, western, and central regions. Sex selection at the third birth following two daughters seems to be very widely prevalent. In the northern region, the SRB at the first order is also more masculine than natural implying that there is some sex selection at the first birth itself indicating that some couples desire to avoid the birth of even one daughter.

Some differences in the SRB by socioeconomic background are seen especially at the second and third births. For the second birth after first daughter, the SRB is generally more masculine than average in the highest education and wealth classes. At the third birth following two daughters, the SRB is highly masculine; this is more so in the most recent period of 2010-14. Further, the SRB is highly masculine at the highest wealth and education levels, in the northern and western regions. Highly masculine SRB is also associated with high media exposure.

Evidence on perceived values of sons vis-à-vis daughters shows that sons are valued for old age support, financial as well as for residence; such reliance is relatively higher in the northern and western regions compared to other regions. Though some changes in attitudes are seen in recent investigations, these are not large enough and parents by and large continue to expect such support primarily from sons rather than from daughters. Besides, in spite of the legal entitlements and provisions, it is not common for daughters to inherit parental property.

The analysis shows that in spite of efforts made by enactment of laws and campaigns by the government and civil society organisations, sex selection has continued. Though some change has been seen in Punjab, Haryana, and Himachal Pradesh, the SRB is yet to return to the natural level in these states. Besides, in recent years, the SRB in some states outside the northern-western region has also become more masculine. Given that son preference is widely prevalent in India, there is a possibility of the practice of sex selection spreading to areas which have hitherto not shown it on a large scale, once the availability of sonographic scan facilities and affordability of the services rise.

It must also be recognised that a large number of girls are 'missing' due to post-natal discrimination, reflected in higher childhood mortality among females than among males. While the matter of gender biased sex selection has been receiving media and policy attention in India, and rightly so, post-natal discrimination rarely figures in public discussions. It is imperative that civil society and policy makers accord due attention to this concern as well and adopt appropriate measures to address it.

Introduction

1

The sex ratio of India's population has been in favour of males in contrast to the situation in most of the world where women outnumber men in the population. In his seminal work on India's sex ratio, Visaria (1968) examined the data up to the census of 1961 and identified higher mortality among females as compared to males as the principal factor responsible for the ratio to be in favour of males in India's population. On the other hand, for the country as a whole, the sex ratio at birth was near the natural level; the ratio is usually close to 105 male births per 100 female births, generally in the range 104 to 106, or around 952 female births per 1000 male births, in the absence of any distortion. However, data since the 1990s have revealed a rise in masculinity in India's sex ratio at birth (SRB) and this issue has been examined in a number of studies (Premi, 2001; Bhat, 2002; Arnold et al., 2002; Bhat and Zavier, 2007; Guilmoto and Attene, 2007; Guilmoto, 2008, 2009). Moreover, it has emerged that gender biased sex selection has been practised especially since the 1990s on a large scale in many parts of the country causing the SRB to become more masculine (Arnold et al., 2002; Jha et al., 2006; Kulkarni, 2007; Visaria, 2007; Kulkarni, 2012; Bongaarts and Guilmoto, 2015). This outcome stems from strong son preference combined with declining fertility and enabled by the availability of and access to pre-natal sex detection technologies, especially the use of sonographic scans.

In populations with son preference, stopping strategies (have children until the desired number of sons is born and then stop childbearing) are often adopted but it is well recognised that such strategies do not alter the SRB (Goodman, 1961). However, sex selection through sex detection and gender biased sex selection does influence the SRB. Such a plan would be adopted by couples who want to have a certain number of sons (or a certain sex composition of children) but at the same time limit the total number of children. This may also be done in case of aversion to children of a particular sex ('daughter avoidance' has often been mentioned in literature). In the past, technology for pre-natal sex detection was not available and hence resorting to gender biased sex selection was not an issue. Female infanticide was practiced to some extent in a few populations and there is evidence of this for parts of India (Visaria, 1968; George et al., 1992), and while this practice affected the child sex ratio it did not affect the SRB per se since infanticide occurs post-birth. However, since the 1980s, pre-natal sex detection has become easily accessible in many parts of the world and with advancement in technology, pre-natal sex selection (also referred to as gender biased sex selection) has engineered a rise in masculinity at birth.

India is not unique to this phenomenon; South Korea, China, Vietnam, and countries around the Caucasus have also seen this practice on a fairly large scale though this has been phased out in South Korea (Guilmoto and Attane, 2007; Guilmoto, 2015; Guilmoto et al. 2018). There is also evidence of such a practice among persons of Indian origin in the United Kingdom (Dubuc and Coleman, 2007). In order to eliminate gender biased sex selection, India has enacted laws to ban pre-natal sex detection; the Pre-Natal Diagnostic Techniques (Regulation

The sex ratio at birth was near the natural level; the ratio is usually close to 105 male births per 100 female births, generally in the range 104 to 106, or around 952 female births per 1000 male births, in the absence of any distortion. However, data since the 1990s have revealed a rise in masculinity in India's sex ratio at birth (SRB)

and Prevention of Misuse) Act, 1994 (PNDT Act), that was amended in 2003 as the Pre-Conception and Pre-Natal Diagnostic Techniques (Prohibition of Sex Selection) Act (PCPNDT Act).

Available evidence shows that, in spite of the Act, the practice of gender biased sex selection persists in India. Since the practice is illegal, it is difficult to have any documented data on the numbers of such cases. However, an estimate of the number of instances of gender biased sex selection, that is, the number of missing female births, may be drawn indirectly from the SRB. Though data on SRB in India are available from various sources, the estimates obtained from different sources do not always agree with the result that there are diverse inferences on the levels and changes in the ratio. Therefore, this study first lists the sources of data on the SRB and presents estimates from these since 1991; for estimates from various sources for earlier periods see Kulkarni (2007; 2009).

The study then discusses the acceptability of various estimates of the SRB to arrive at the most plausible estimates. These values of the SRB have then been used, in conjunction with estimates of the numbers of births, to estimate the numbers of missing female births..

The study estimates the number of missing girls at the 2011 census enumeration and presents its decomposition by the two factors, pre-natal discrimination and post-natal discrimination

The practice of gender biased sex selection, resulting from 'pre-natal discrimination' against females, is only one factor causing female deficit. Higher than expected female childhood mortality, due to neglect of the girl child, called 'post-natal discrimination', is the other factor that causes female deficit; in fact, the pioneering work on estimation of missing women by Sen (1990) and Coale (1991) was in the context of this factor. Hence, the study estimates the number of missing girls at the 2011 census enumeration and presents its decomposition by the two factors, pre-natal discrimination and post-natal discrimination. This has been done for girls of ages 0-6, since the child sex ratio for this age group is commonly used in India in discussions on female deficit. Further, for the five-year period beyond the 2011 census, estimates of missing female births and excess deaths of girls below age five have been obtained.

The study also examines how the SRB varies by the stage of family building, that is, at different birth orders and by the sex composition of previous births up to the third order. This aids an understanding of the location of sex selection within the reproductive span. This is followed by an examination of socioeconomic and spatial differentials in the sex ratio at birth at various stages of family building and an assessment of the net influences of various factors on the probability of a male birth at orders up to the third. Finally, the study looks at recent evidence on reasons for son preference and, in particular, on values of sons vis-à-vis daughters.

Sex selection, in addition to being intrinsically undesirable, also has adverse implications for the society causing sex imbalances in the society. The impact of such sex imbalance on marriage squeeze in India has been examined in paper by Kaur (2004), Guilmoto (2012), and Kaur et al. (2016) and is not the subject matter of the present study.

In international convention, the SRB is expressed in terms of number of male births per 100 female births. However, in India SRB is traditionally presented as number of female births per 1000 male births and hence ratios in this convention are presented in the tables in this study. In this convention, a lower SRB means higher masculinity at birth. The conversion from SRB in one convention to another is straight forward:

SRB (male births per 100 female births) = 100000/ SRB (female births per 1000 male births).

2

Estimates of Sex Ratio at Birth from Different Sources of Data

A number of independent data sets allow estimation of the sex ratio at birth. These include the Civil Registration System (CRS), the Sample Registration System (SRS), the decennial censuses, and the National Family Health Surveys (NFHS). Besides, some other surveys, and administrative records including the Health Management Information System (HMIS) also give relevant data.

2.1 Civil Registration System

The CRS has been in operation in India for a long time. Initially, registration of births and deaths was voluntary but after the enactment of the Registration of Births and Deaths Act in 1969 it is mandatory to register all births and deaths. The ORGI publishes annual reports that provide data on registration and these give SRB for India and states and union territories. However, for some years, tabulations of births by sex are not available for a few states. Though the level of completeness of coverage of civil registration of births has shown an impressive rise from 56 percent in 2000 to 86-88 percent during 2014-2016, the coverage is far from complete (Registrar General, 2019a). Since registration can be sex selective, the estimates of SRB are likely to be biased (newborn boys are more likely to be registered than girls, as noted by Visaria, 1968) and this is a limitation that needs to be noted. Trends in the SRB according to the CRS since 1991 are shown in Table 1. At the national level, the SRB has fluctuated between 857 and 909; the lowest value was seen in the year 2010, however, this appears to be an outlier as this is much different from the values for 2009 (898) and 2011 (909). Overall, the SRB was highly masculine throughout the period; the level was somewhat higher during 2007 to 2013 (except the year 2010 when it was unusually low) but there does not seem to be any discernible long-term trend.

Since registration can be sex selective, the estimates of SRB are likely to be biased

2.2 Sample Registration System (SRS)

The Sample Registration System (SRS) was introduced in India in 1964-65 on a pilot basis and in 1969 on a regular basis since the Civil Registration System did not have a good coverage at the time. The SRS has been providing estimates of fertility and mortality on a regular basis since 1970 (Registrar General, 2019). The SRS is a dual record system with continuous registration and half-yearly

retrospective surveys that are matched and corrected. In 2017, the sample of the SRS covered 8850 units (4961 rural and 3889 urban) which had a total population of 7.9 million. For the SRB, estimates for India and large states are available as three-year moving averages since 1998-2000 (some estimates prior to this period are available for India as a whole). Since the SRS, as the name shows, is based on registration in a sample of geographic units, sampling errors can be large and the organisation gives three-year averages of the SRB rather than single year estimates. The estimates for the three-years 1990-92 to the years 2015-2017 are presented in Table 1. According to the SRS estimates, the SRB has been quite low, below 910, well below the natural level, throughout the period. There was an apparent rise in the masculinity in the SRB during the first few years of the century with the SRB falling to 880 and a mild recovery seen after 2003-2005 but a small decline after 2012-14. Since the SRS changed the sample units in 2004 and again in 2014 (the SRS normally changes the sample units every 10 years, using the latest census as the frame), some of these turnarounds may be attributable to these changes. Notwithstanding the possible effect of changes in the sample, the SRS estimates show a highly masculine SRB in recent decades.

2.3 Census

The study estimates the number of missing girls at the 2011 census enumeration and presents its decomposition by the two factors, pre-natal discrimination and post-natal discrimination

The Indian census is decennial and has been organized regularly for over a century. Since 1981, the census has questions on 'births last year' to married women and on 'the number of children ever born' as well as 'the number of surviving children' to ever married women. This information is tabulated by sex of children and age of women which allows us to compute the sex ratio of births last year and of all births to women. The SRB based on births last year (BLY) refers to the one–year period before the census enumeration. One cannot specify a reference period for the SRB based on all births (children ever born-CEB) since these births would have occurred over a long period; for the younger women the births would be recent but for older women, many of these births would have occurred some time ago. Hence we compute the SRB based on births to women in the age range 20-29, labeled CEB (20-29), as almost all of these births would have occurred during a period of 10-15 years before the census and most during the 10-year period before the census. Though no specific 'reference period' as such can be given for this SRB, it does refer to a recent period. The BLY and CEB (20-29) estimates based on 2001 and 2011 censuses are given in the last column of Table 1.

Further, the censuses provide age-sex distribution. In public discourses and the media, the child-sex ratio has often been used to comment on the level of SRB and by implication on sex selection. The child sex ratio for the age group 0-6 is commonly used in India because this ratio is available soon after the census whereas tabulations on complete age-sex distribution take longer time. Strictly speaking, child sex ratio is not identical to SRB since child sex ratio is influenced by sex differentials in early childhood mortality in addition to the SRB. But if information on child mortality by sex is available, one can estimate the SRB from the child sex ratio indirectly by applying the technique of reverse survival. For this purpose, age groups such as 0-4 or 5-9 may be used in order to estimate recent SRB. However, sex selective misreporting of age and sex selective omission can distort this ratio. It has been seen that such an effect is minimal in the age range 0-6 (Bhat, 2002) and hence it is preferable to estimate the SRB based on the child sex ratio for the ages 0-6. Kumar and Sathyanarayana (2012) have obtained such estimates from the 2001 and 2011 census data. These refer to the seven-

Table 1: Estimates of sex ratio at birth from various sources, India, 1991-2017

(female births per 1000 male births)

Year/ mid-year of period	Source								
	CRS	SRS @	NFHS-3		NFHS-4		HMIS	Census based	
			Annual	MA $	Annual	MA $			
1991	865	900	870	947	859	850			
1992	863	894	957	925	865	858			
1993	863	885	937	915	840	868			
1994	862	879	913	933	894	876		*Based on*	
1995	870	883	897	928	877	882		*2001 Census*	
1996	869	891	969	926	897	894		CEB 20-29	939
1997	881	901	929	930	895	901			
1998	883		928	938	907	899		Indirect	935
1999	895	898	933	928	926	905			
2000	886	894	936	933	871	919		BLY	906
2001	875	892	914	927	929	921			
2002	872	883	956	919	963	917			
2003	868	882	894		917	925			
2004	872	880	894		908	923		*Based on*	
2005	876	892			907	916		*2011 Census*	
2006	891	901			920	916		CEB 20-29	928
2007	903	904			928	919			
2008	904	906			920	912	900	Indirect	923
2009	898	905			919	909	927		
2010	857	906			875	909	913	BLY	899
2011	909	908			902	913	917		
2012	908	909			931	911	915		
2013	898	906			942		918		
2014	887	900			905		918		
2015	881	898					923		
2016	877	896					926		
2017							929		

@: Three-year moving average; $: MA: Five-year moving average.
CEB (20-29): Children ever born to women of ages 20-29 at the census. BLY: Births last year.
Indirect: Indirect estimate computed by applying reverse survival to child sex ratio (ages 0-6).
Sources: CRS (Civil Registration System): Registrar General (2013a, 2018a);
SRS (Sample Registration System): Registrar General (various years, 2001-2018);
NFHS-3 and 4 (National Family Health Survey-3, -4): Computed from NFHS-3, -4 data files;
HMIS (Health Management Information System): HMIS (2018);
Census based: CEB and BLY estimates computed from 2001 and 2011 Census fertility tables;
Census based: Indirect estimates from Kumar and Sathyanarayana (2012).

year periods before the census, that is, March 1994-February 2001 and March 2004-February 2011 or roughly 1994-2000 and 2004-2010 based on the 2001 and 2011 censuses respectively. These estimates, labeled indirect estimates, are also shown in Table 1.

The three estimates of the SRB, from BLY, CEB (20-29), and indirect from child sex ratio, do vary somewhat. The ratio based on BLY is lower than that based on CEB (20-29). The estimate based on BLY refers to the last year before the census whereas that based on CEB(20-29) refers to a longer period before the census and higher values for the latter may indicate that the SRB has been falling over the years prior to the census. However, it is seen that while the number of births reported as BLY in the 2001 census was 19.9 million, the estimated number of births by applying the SRS birth rate to the then population would be close to 26.3 million. Similar figures for the 2011 census are: reported births last year 20.9 million and estimated births 26.5 million. Thus, a large number of births that occurred in the previous year were not reported in the censuses as births last year. In view of this, an inference on trends is not warranted merely from a comparison of the estimates. Incidentally, the indirect estimates from the census child sex ratios are close to those based on CEB(20-29) for both the censuses.

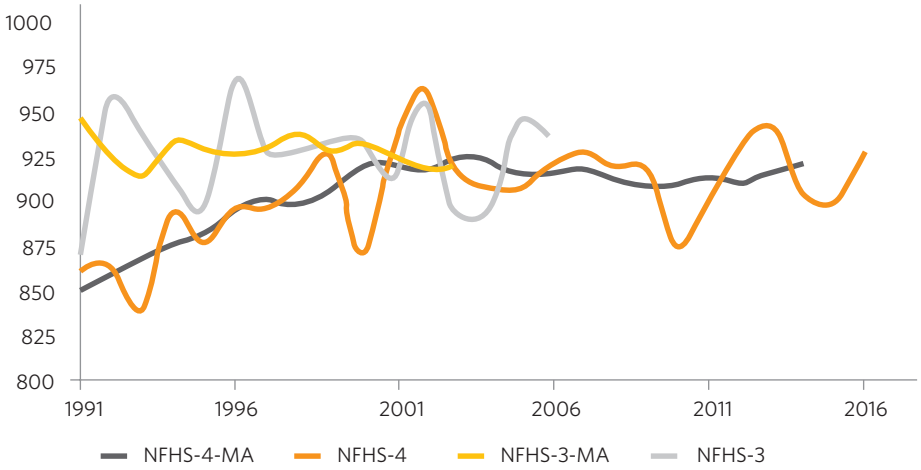
2.4 National Family Health Surveys (NFHS)

The NFHS data files allow an examination of SRB by the sex composition of previous births in order to see how the SRB is influenced by sex preference, especially son preference

The National Family Health Survey (NFHS) is the Demographic and Health Survey (DHS) for India and four rounds of the NHFS have been carried out in India so far; the latest round (NFHS-4) was in 2015-16 and the previous (NFHS-3) in 2005-06. The surveys have a large sample size and this was particularly so in NFHS-4; 6,01,509 households and 6,99,686 women of ages 15-49 were interviewed in NFHS-4 and 1,09,041 households and 1,24,385 women of ages 15-49 interviewed in NFHS-3 (International Institute for Population Sciences (IIPS) and Macro International, 2007; International Institute for Population Sciences (IIPS) and ICF, 2017). Since the NFHS obtained complete fertility histories, it is possible to compute SRB for various time periods; the NFHS data files also allow an examination of SRB by the sex composition of previous births in order to see how the SRB is influenced by sex preference, especially son preference, an issue that will be addressed in a later section. Estimates of SRB for India for calendar years up to 2004 for NFHS-3 and up to 2014 for NFHS-4, the last complete years covered in the two surveys respectively, are obtained from the NFHS-3 and NFHS-4 data files; sample weights provided in NFHS data files have been applied.

The estimates are presented in Table 1 and in Fig.1. There was a gap of 10 years between the NFHS-3 and the NFHS-4 and hence for the years prior to 2005, estimates are available from both the surveys. It is seen that the NFHS-4 estimates for the years 2000 to 2002 are slightly lower (more masculine) than those from the NFHS-3, and for earlier years, the NFHS-4 shows much lower values. It is likely that for children born long ago, more than 10 years before the survey, there is selective omission of girls in reporting. One plausible reason is that, the NFHS being a retrospective enquiry, births of daughters who were married by the survey date may not have been reported by some women in the survey. Regardless of the reasons for such omission, it is not advisable to draw inferences based on the NFHS estimates referring to periods much beyond 10 years before the date of the survey. Further, since the NFHS are sample surveys, the estimates have sampling errors as a result of which fluctuations are seen in the annual series (Fig. 1). Hence, five-year averages have also been computed and presented in Fig. 1 and in Table 1.

Fig.1: Trends in SRB based on NFHS-3 and NFHS-4, India, annual estimates and five-year moving averages (female births per 1000 male births)



Note: MA: Five-year Moving Average; these values are shown against the mid-year in the graph. Source: Table 1.

From the NFHS-3 series, it is seen that the SRB (five-year average) was fairly stable from 1992 to 2002 (the last middle year for which five-year average could be computed from the NFHS-3), fluctuating mildly around 925 female births per 1000 male births. The NFHS-4 series since 2000 shows a slightly lower SRB, fluctuating around 915 up to 2012 (the last middle year for which five-year average could be computed from the NFHS-4). Thus, the two surveys show lower than natural SRB in India fluctuating in the range 910 to 935 female births per 1000 male births over the period 1992 to 2012 (ignoring the NFHS-4 estimates for years before 2000 for reasons noted above).

Two rounds of National Family Health Surveys (NFHS) show lower than natural SRB in India fluctuating in the range 910 to 935 female births per 1000 male births over the period 1992 to 2012

The India Human Development Survey (IHDS) is another series of large surveys which also collect data on fertility; this survey was conducted during 2004-05 and again in 2011-12 (IHDS, 2018). The first round of the IHDS (IHDS-1) nearly coincides with the NFHS-3 and the report showed that at the national level 52 percent of births were boys (based on births during the 10-year period before the survey). This is equivalent to an SRB of 923 female births per 1000 male births which is close to the NFHS-3 estimate for the period which is 930 for 1995-99 and 919 for 2000-2004.

2.5 Health Management Information System (HMIS)

The HMIS is a relatively new system introduced by the Ministry of Health and Family Welfare of the Government of India as part of the National Health Mission to collect information on various aspects of health services in order to monitor the performance of the programme (HMIS, 2018). The information is provided by health workers and institutions and data at the district level are uploaded to the Health Statistics Information Portal using a web based Health Management Information System (HMIS) interface. Periodic reports are made available by the system. The information pertains to services by both the public and the private sectors. The HMIS reports since 2008-09 (monthly, quarterly, and annual, at national, state, and district level) are available on the website and the sex ratio at birth has been included in the reports. The values of SRB from this system are shown in Table 1.

Except for the first year of information, 2008-09, the SRB for India has been in the range 913 and 929. Thus, it is moderately below the natural level.

It should be noted that the system is getting established and the coverage is not complete; the system also gives the level of coverage of births and this has been hovering around 75-80 percent in recent years (HMIS, 2018). There is a possibility that reporting of births has some sex selectivity, and this could bias the estimates to that extent.

2.6 Regional variations

States in the northern-western region show very low ratios, notably Punjab, Haryana, Chandigarh, Delhi, Rajasthan, Himachal Pradesh, Gujarat, Maharashtra, and Uttarakhand

The various sources provide estimates for states and union territories as well though the SRS estimates are only for large states; estimates for states/union territories are given in Appendix Tables. Geographic variations in the SRB are very conspicuous and seen across all the sources though the precise values do vary. States in the northern-western region show very low ratios, notably Punjab, Haryana, Chandigarh, Delhi, Rajasthan, Himachal Pradesh, Gujarat, Maharashtra, and Uttarakhand. In some of these states, the ratio seems to have become less masculine over the period; in particular, Himachal Pradesh and Punjab show a distinct improvement though the ratio in Punjab continues to be more masculine than the natural level. On the other hand, in all the southern states, in West Bengal, Odisha, Chhattisgarh, and in the northeastern states, the SRB is generally close to the natural level. A few of these did show high masculinity based on the CRS data in a few years, but otherwise have SRB within the range 935 to 970 with no clear trend.

Kumar and Sathyanarayana (2012) provide district level estimates of the SRB based on the census 0-6 sex ratio via reverse survival and these are depicted in a map (Map 2 in their paper). These allow one to see a more disaggregated spatial pattern of the SRB than what is seen from estimates at the state level.

3

Correspondence among Various Estimates

As seen in Table 1, the estimates of SRB for India as obtained from various sources do not always agree. This calls for a comparative assessment of the estimates from the available sources. The SRS estimates are for three-year periods and hence similar three-year averages are obtained from the annual estimates from the CRS. For comparing NFHS estimates, only the estimates for the recent periods are used since, as noted earlier, the NFHS estimates for periods 10 years before the survey are highly masculine because of a likelihood of omission of daughters born well before the survey in the retrospective enquiry. Moreover, five-year averages of the NFHS are used since the annual estimates have large sampling errors. Fig. 2 presents a comparative view of the estimates of SRB for various years and time periods. It is seen that the three-year averages from the CRS are lower than the corresponding SRS estimates by about 10 points. A lower value from the CRS should not come as a surprise since registration of sons is more likely than that of daughters. Further, the SRS estimates are lower than those from the NFHS-3 and NFHS-4 though the very recent SRS estimates are quite close to the NFHS ones for the corresponding periods. The recent HMIS estimates are also close to the NFHS estimates.

The estimate based on the sex ratio for ages 0-6 in the 2001 census refers to the period 1994-2000 which is 935 whereas the SRS estimate for roughly the same period is 895

Of the census based estimates, those from BLY (births last year) are close to the SRS estimates for the corresponding years. However, the estimates implied by the child sex ratios, obtained indirectly by reverse survival, are higher than the SRS estimates for the corresponding periods (a comparative picture can be seen from the lower panel in Table 2). The estimate based on the sex ratio for ages 0-6 in the 2001 census refers to the period 1994-2000 which is 935 whereas the SRS estimate for roughly the same period is 895. The estimate from the 2011 census referring to 2004-10 is 923 whereas the average of SRS estimates for roughly the same period is 903[1]. The CEB (20-29) estimates from the births to women of ages 20-29 are slightly higher than the ones implied SRB, by about five points. But, as these do not have a clearly defined reference period, it is not possible to compare these with others. In addition to the sources noted in the previous section, the United Nations Population Division also provides population data base for all countries in the reports on world population prospects and the values of SRB for India for five-year periods according to the latest publication (U.N., 2019) are 1.106, 1.111, 1.112, 1.101, 1.099, and 1.099 (expressed as ratios of male births to 100 female births) for the periods 1990-95, 1995-2000, 2000-2005, 2005-2010, 2010-2015,

1 Since the SRS does not give annual figures but only three-year averages, and there are some gaps in the SRS series of SRB estimates, it is not possible to get the averages precisely for the seven-year periods 1994 to 2000 and 2004 to 2010 and hence the average of the estimate for 1995-97, centered on 1996 and of 1998-2000 centered on 1999, is used for comparison with the 2001 census based estimate for 1994-2000 and the average of 2005-07 and 2008-10 estimates is used for comparison with the 2011 census based estimate for 2004-10.

2015-2020 respectively; in terms of female births per 1000 male births, these are: 904, 900, 899, 908, 910, and 910. These are close to the SRS estimates though not identical; the U.N. estimate for 2000-05 is much higher than that by the SRS.

Fig.2: Comparison of estimates of SRB from various sources, India

(female births per 1000 male births)

Source: Table 1; SRS- corrected series based on correction of 0.978 to SRS estimates

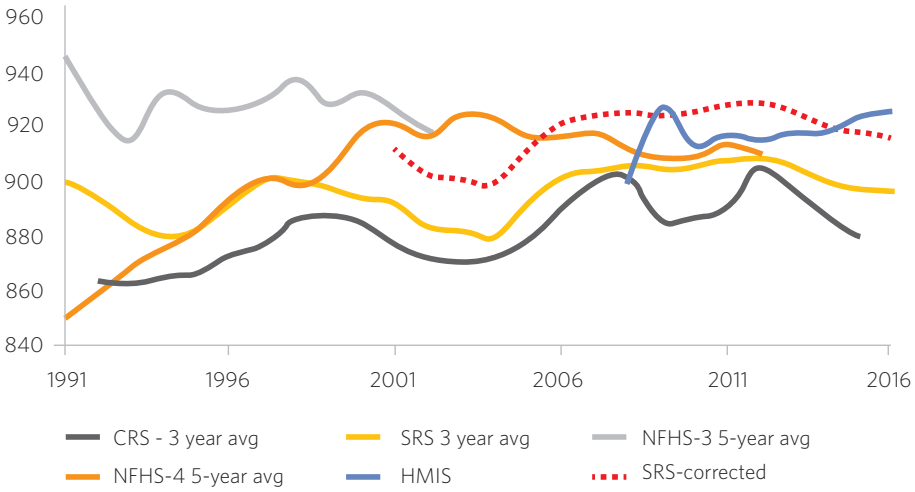


Table 2: Comparison of estimates of SRB from various sources for the periods 1994-2000 and 2004-10, India

(female births per 1000 male births)

Period	CRS	SRS	NFHS		Indirect from Census Child sex ratio, ages 0-6
			NFHS-3	NFHS-4	
1994-2000					
Estimate	878	895	929		935 (2001 census)
Ratio to 2001 Census Indirect estimate	0.939	0.957	0.994		
2004-10					923
Estimate	886	903		911	(2011 census)
Ratio to 2011 census indirect estimate	0.960	0.978		0.987	

Source for estimates: Table 1.

Note: the CRS, SRS and NFHS estimates are averages for the specified periods.

Thus, we see that the estimates do differ; the CRS estimates and the census based estimates from BLY are lower than the SRS estimates which, in turn, are lower than the NFHS five-year averages, and the census child sex ratio based implied estimates[2]. If registration of births is sex selective, with the likelihood of registration being higher for males, the CRS and SRS would underestimate the SRB (as measured in terms of female births per 1000 male births). But it is also conceivable that census enumeration favours females and this overestimates the child sex ratio (females per 1000 males) in the census and consequently the SRB computed from it. However, results from the post enumeration survey (PES) of the 2011 census show that there is hardly any sex-selective omission in early ages (Registrar General, 2014a). The net omission rates are 32.57 per 1000 for males and 32.57 for females for the age group 0-4 and 22.92 per 1000 for males and 22.17 for females for the 5-9 age group.

2 For a recent work on comparison of estimates of SRB, see Rajan et al. (2017).

The slight difference in the net omission rates in the 5-9 age group does not impact the child sex ratio for 0-6 ages by even one point. Thus, the SRB implied by the child sex ratio does not appear to have been affected by sex selective under-enumeration.

Moreover, as noted earlier, sex selective age misreporting has very little effect on the 0-6 age group taken as a whole. Further, migration at very young ages is generally not sex selective and hence would not influence the child sex ratio. The computation of SRB from the child sex ratio does involve assumptions of sex differentials in early childhood mortality. However, minor departures from such assumptions do not affect the estimate notably. The child sex ratio from the 2011 census is 919 females per 1000 males and the SRB would not be lower than this value unless female early childhood mortality is lower than male mortality whereas all evidence points towards higher female than male mortality during early childhood in India. According to the SRS report for 2011, the under-five mortality rate was 59 per thousand for females and 51 per thousand for males (under-five mortality rates by sex are available in recent reports of the SRS; see Registrar General, various years). Given the evidence on sex differentials in child mortality (which shows higher childhood mortality among females than males) and on omission rates (which do not vary by sex) in census enumeration, estimates of SRB showing lower masculinity than the census child sex ratios are not tenable.

In view of this, the indirect estimates obtained from the child sex ratios may be accepted as the most plausible. However, these are available only once in ten years and do not give a time series to assess changes over short periods. On the other hand, the SRS give a continuous series but these are seen to be underestimates of the female births to male births ratio. One could then correct the SRS estimates on the basis of the ratio of SRS estimate to the indirect census based estimate for the same period. These ratios, shown in Table 2, are 0.957 based on 2001 census and 0.978 based on 2011 census. For the recent period, the correction of 0.978 as obtained from the 2011 census may be applied. Thus the SRS estimate may be corrected by dividing it by 0.978 in case of female births to male births ratio; as a round figure, the correction amounts to raising the SRS estimate by 2 percent. The estimates so corrected from 2000 onwards are shown in Fig.2 along with the direct estimates. After applying the correction, India's SRB during 2000-2016 fluctuates in the range 899 to 929 (rounded to 900 to 930) female births per 1000 male births with no clear trend.

In a recent analysis, Kaur et al. (2016) also noted a mismatch between the SRS estimate and indirect census based estimates of the SRB and adjusted the SRS estimates on the basis of the relationship between SRB and child sex ratio through child mortality rates (for details see Appendix –I of the paper cited). For the recent years, the adjusted values of SRB are higher than the SRS estimates by 2-3 percent (females per 1000 males) at the all-India level, close to the correction noted above. For periods before 2000, the correction is higher, by about four percent, which is in line with the correction factor of 0.957 based on the 2001 census shown in Table 2.

The SRS give a continuous series but these are seen to be underestimates of the female births to male births ratio. One could then correct the SRS estimates on the basis of the ratio of SRS estimate to the indirect census based estimate for the same period

After applying the correction, India's SRB during 2000-2016 fluctuates in the range 899 to 929 female births per 1000 male births with no clear trend

Table 3: Comparison of estimates of SRB from various sources for the period 2004-10, India and large states

India/state	Estimates of SRB for the period 2004-10 from various sources (female births per 1000 male births)				Ratios to indirect census based estimate		
	CRS 2004-2010 Average	SRS 2005/07 & 2008/10 average	NFHS-4 2004-2010	Indirect estimate based on 2011 census	CRS est./ Census indirect	SRS est. / Census indirect	NFHS-4 est./ Census Indirect
India	886	903	911	923	0.960	0.978	0.987
Andhra Pradesh β	980	917	915	938	1.045	0.978	0.975
Assam	888	933	959	961	0.924	0.971	0.998
Bihar	$	910	930	943	$	0.966	0.986
Chhattisgarh	916	977	951	971	0.943	1.006	0.979
Delhi	874	877	787	873	1.001	1.005	0.901
Gujarat	885	897	910	895	0.989	1.002	1.016
Haryana	840	845	818	845	0.994	1.001	0.969
Himachal Pradesh	894	936	965	916	0.976	1.022	1.053
Jammu & Kashmir α	918	863	933	866	1.060	0.997	1.077
Jharkhand	854	923	946	958	0.891	0.963	0.987
Karnataka	973	934	934	949	1.026	0.985	0.984
Kerala	947	962	961	965	0.981	0.997	0.996
Madhya Pradesh	892	917	921	923	0.966	0.993	0.998
Maharashtra	850	883	856	896	0.949	0.985	0.955
Orissa	925	935	938	942	0.982	0.993	0.996
Punjab	812	834	837	854	0.950	0.977	0.980
Rajasthan	824	871	877	897	0.918	0.971	0.978
Tamil Nadu	934	935	928	942	0.992	0.993	0.985
Uttar Pradesh	$	875	909	914	$	0.958	0.995
West Bengal	913	937	938	954	0.957	0.982	0.984

Source for estimates: Appendix tables 1-5

β : Including Telangana; α ; Including Ladakh; $: Data for some years are not available.

A comparison of estimates for large states is shown in Table 3 for the period 2004-10. It is seen that in a majority of states, the ratio of SRS estimate to census child sex ratio based estimate is close to 0.98, that is, the SRS estimates are lower (showing greater masculinity) than the child sex ratio based estimates by about two percent. The SRS estimates are lower by more than two percent in Uttar Pradesh, Bihar, Jharkhand, Rajasthan, and Assam. On the other hand, in a few states, the SRS estimates are very close to the census based estimates with the difference being less than one percent. Thus, the SRS estimates seem to be acceptable in these states but require a small correction at the national level and for other states.

4

Estimates of Numbers of Missing Girls and Missing Female Births

A lower (more masculine) than natural SRB obviously implies the occurrence of gender biased sex selection. Such sex selection against female births, indicates pre-natal discrimination, and is one factor causing female deficit in the population. Departure of the SRB from the natural level, in conjunction with the number of births, gives an estimate of the number of missing female births provided there is no sex bias in reporting of births. The other factor behind relative female deficit in population is excess female mortality. Generally female mortality is lower than male mortality. Maternal mortality does certainly raise female mortality in childbearing ages but with substantial decline in this, female disadvantage relative to males is no longer an issue. However, in some populations, female mortality is higher than male mortality even during childhood and in some, female childhood mortality is lower than male mortality but not as low as seen in populations at a similar level of male mortality. Female mortality higher than that expected at the prevailing level of male mortality is attributed to female neglect in health and nutrition, which amounts to post-natal discrimination. Using demographic techniques, one can estimate the size of female population at a given age that would have been present at a time point in the absence of pre- and post-natal discrimination and the difference between this number and the number actually enumerated at that time point is the number of 'missing women'. A number of researches have provided estimates of numbers of missing female births as well as estimates of missing women for a number of countries including India; for recent work, see Bongaarts and Guilmoto (2015) and Kashyap (2019). Some India specific studies are by Arnold et al. (2002), Bhat (2002), Jha et al. (2006), Kulkarni (2007), and Kaur et al. (2017).

Female mortality higher than that expected at the prevailing level of male mortality is attributed to female neglect in health and nutrition, which amounts to post-natal discrimination

In this study, we estimate the number of missing female births as well as the number of missing females of young ages, or missing girls, on the basis of India's 2011 census enumeration. Age misreporting can obviously influence the estimates and hence we choose the age group 0-6, which, as noted earlier, is least affected by sex selective misreporting. Thus, the estimates of missing female births refer to the seven-year period preceding the 2001 census, that is, March 2004 to February 2011 since March 1, 2011 is the reference date for the 2011 census enumeration. The estimated numbers of missing girls are reckoned as on March 1, 2011. The procedure has been described in the Appendix.

The estimation has been done for India and for large states for which data on life tables are available and the results are shown in Table 4. The estimates show that there were 2.6 million missing female births in India during 2004-2011, an annual average of 378 thousand which amounts to 3.1 percent of female births. Estimates of annual number of missing female births by Bongaarts and Guilmoto for the periods 2000-2005 and 2005-2010 are 0.62 million and 0.63 million respectively. These estimates are higher than that in the present study primarily because the Bongaarts and Guilmoto paper is based on the U.N. estimates of SRB which are more masculine than the census based indirect estimate of the SRB used here. The numbers of missing female births per annum are high in Uttar Pradesh and Maharashtra (over 50 thousand) and moderate in Rajasthan, Gujarat, Haryana, Madhya Pradesh, and Punjab (25 thousand or more). In relative terms (number of missing female births as percent of female births), Haryana and Punjab are very poorly placed: missing female births amounted to over 10 percent of female births in these states, followed by Delhi, Jammu and Kashmir, Gujarat, Maharashtra, Rajasthan, Uttar Pradesh, Himachal Pradesh and Madhya Pradesh. On the other hand, in some states, Chhattisgarh, Kerala, Assam, Jharkhand and West Bengal, the SRB during 2004-2011 was above 952; clearly gender biased sex selection did not take place on a notable scale in these states. Note that estimates for small states have not been obtained here since the SRS provides some of the necessary data only for large states. However, estimates of the SRB by Kumar and Sathyanarayana (2012) show that the SRB during 2004-2011 for most of the states in the northeastern region was higher than 952 and gender biased sex selection was obviously not common in these states.

It is seen that nationally about four million girls of ages 0-6 were missing at the 2011 census. Of these, 2.5 million were missing due to gender biased sex selection (pre-natal discrimination) and 1.5 million due to excess female mortality (post-natal discrimination)

Estimates of the total number of missing girls and also the decomposition by pre-natal and post-natal discrimination are provided in Table 4. It is seen that nationally about four million girls of ages 0-6 were missing at the 2011 census. Of these, 2.5 million were missing due to gender biased sex selection (pre-natal discrimination) and 1.5 million due to excess female mortality (post-natal discrimination).[3] The relative contributions of pre-natal and post-natal discriminations are in the rough ratio of 5:3.

In Haryana, Punjab, Jammu and Kashmir and Delhi the number of missing girls of ages 0-6 is 10 percent or more of the enumerated girls of this age. In terms of volume, Uttar Pradesh, Maharashtra, Rajasthan, Bihar, Gujarat, Madhya Pradesh, Haryana have large numbers of missing girls. The relative shares of pre-natal and post-natal discrimination vary across states. In Delhi, Maharashtra, Punjab, Jammu and Kashmir, and Haryana over 80 percent and in Gujarat, and Himachal Pradesh over 70 percent of missing girls are missed on account of pre-natal discrimination. As seen above, Chhattisgarh, Kerala, Assam, Jharkhand and West Bengal do not seem to have notably high prevalence of gender biased sex selection. However, even in these states there is evidence of some post-natal discrimination. In addition, in Karnataka, post-natal discrimination dominates the count of missing girls. In Rajasthan, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Odisha, and Bihar both the factors have substantial shares in contributing to the number of missing girls.

3 The number of missing girls in the 2011 census due to pre-natal discrimination is slightly less than the number of missing female births during the preceding period of seven years because the missing girls due to pre-natal discrimination are the 'expected numbers of survivors' on March 1, 2011 of the missing female births during the preceding period.

Table 4: Estimates of numbers of missing girls of ages 0-6 at 2011 census enumeration and missing female births during 2004-11, India and large states

	Number of missing female births during 2004-11 (in thousands)			Number of missing girls 0-6 at 2011 census enumeration (in thousands)			Number of missing girls 0-6 at 2011 census enumeration as percent of enumerated girls		
	Total	Annual	as % of female births	Total	Missing due to		Total	Missing due to	
					GBSS	EFCM		GBSS	EFCM
India	2646	378	3.1	4007	2515	1492	5.1	3.2	1.9
Andhra Pradesh β	72	10	1.5	112	69	43	2.5	1.5	1.0
Assam	neg	neg	Neg	32	neg	32	1.4	0.0	1.4
Bihar	103	15	1.0	309	98	211	3.3	1.1	2.3
Chhattisgarh	neg	neg	Neg	30	neg	30	1.7	0.0	1.7
Delhi	88	13	9.1	94	86	8	10.0	9.2	0.9
Gujarat	250	36	6.4	307	238	69	8.4	6.5	1.9
Haryana	211	30	12.7	241	201	40	15.6	13.0	2.6
Himachal Pradesh	15	2	3.9	21	15	7	5.8	4.0	1.8
Jammu & Kashmir α	93	13	9.4	107	90	18	11.5	9.6	1.9
Jharkhand	neg	neg	neg	62	neg	62	2.4	0.0	2.4
Karnataka	11	2	0.3	47	11	36	1.3	0.3	1.0
Kerala	neg	neg	neg	6	neg	6	0.3	0.0	0.3
Madhya Pradesh	180	26	3.2	285	167	118	5.5	3.2	2.3
Maharashtra	411	59	6.3	456	400	56	7.2	6.3	0.9
Odisha	29	4	1.0	68	27	41	2.7	1.0	1.6
Punjab	172	25	11.5	193	166	27	13.6	11.8	1.9
Rajasthan	339	48	6.1	452	317	135	9.0	6.3	2.7
Tamil Nadu	41	6	1.1	59	40	19	1.6	1.1	0.5
Uttar Pradesh	679	97	4.2	1113	634	480	7.6	4.3	3.3
West Bengal	neg	neg	neg	30	neg	30	0.6	0.0	0.6

GBSS: Gender biased sex selection

EFCM: Excess female childhood mortality

neg: negligible.

β : Including Telangana. α: Including Ladakh.

Source: Computations by the author.

Such an estimation of missing girls is not possible for the post-2011 census period until the next enumeration takes place; this will occur in the 2021 census. However, we do have data on SRB from the SRS for some years after 2001 and these can be used to estimate the numbers of missing female births for a period of five years after the enumeration and excess female childhood mortality. The procedure has been described in the Appendix and the results are given in Table 5.

Table 5: Estimates of missing female births during 2011-16 and excess female deaths before age 5 for births of 2011-16, India and large states

State	Missing female births during 2011-16			Excess female deaths before age 5 among births during 2011-16	
	Total (in thousands)	Annual (in thousands)	as % of female births	Number (in thousands)	as % of female births
INDIA	1941	388	3.0	895	1.4
Andhra Pradesh β	63	13	1.7	37	1.0
Assam	27	5	1.5	31	1.8
Bihar	80	16	1.1	93	1.3
Chhattisgarh	neg	neg	neg	31	2.0
Delhi	65	13	9.5	6	0.8
Gujarat	238	48	7.8	31	1.0
Haryana	156	31	12.2	19	1.5
Himachal Pradesh	12	2	4.5	1	0.4
Jammu & Kashmir α	26	5	5.0	5	0.9
Jharkhand	13	3	0.6	31	1.6
Karnataka	neg	neg	neg	26	0.9
Kerala	neg	neg	neg	6	0.5
Madhya Pradesh.	127	25	2.7	93	1.9
Maharashtra	249	50	5.5	27	0.6
Orissa	neg	neg	neg	25	1.2
Punjab	66	13	6.3	12	1.2
Rajasthan	225	45	5.2	108	2.5
Tamil Nadu	77	15	2.8	15	0.5
Uttar Pradesh	667	133	4.9	312	2.3
West Bengal	neg	neg	neg	35	0.8
Uttarakhand	37	7	9.6	3	0.9

β: *Including Telangana;* α: *Including Ladakh;* *neg: Negligible.*

Source: Computations by the author.

It is estimated that the number of missing female births in India during 2011-2016 was 1,941 thousand or about two million, an average of 388 thousand per year and amounts to three percent of female births, close to the estimate for the period 2004-2011. Essentially, the SRB has fluctuated since 2000 but not shown a clear trend and hence the degree of sex selection has remained fairly steady. The estimate by Bongaarts and Guilmoto (2015) for the period 2010-15 is 0.63 million per year; this is higher than our estimate of 0.388 million because Bongaarts and Guilmoto have used the U.N. estimate of SRB which is more masculine than the adjusted value of SRB used in the present study. Kashyap (2019) has given an estimate of 1536.3 thousand for the period 2010-15, lower than our estimate of 1941 thousand; this is due, in part, to some difference in the methodology adopted and

in part, due to the adjustment in SRB made in the present study (see Guilmoto et al., 2020, for a discussion on the differences in methodology).

The geographic pattern is fairly similar to that observed for the period 2004-2011. The number of missing female births is very high in Uttar Pradesh, Maharashtra, Gujarat, Rajasthan, Haryana and Madhya Pradesh. In Chhattisgarh, Karnataka, Kerala, Odisha, and West Bengal, there is no evidence of such sex selection on a notable scale. In relative terms (assessed in terms of the number of missing female births as percent of female births), Haryana shows the highest level (12.2 percent) followed by Uttarakhand, Delhi, Gujarat, Punjab, Maharashtra, Uttar Pradesh, Himachal Pradesh, and Jammu and Kashmir. In other states, the relative level is low. Punjab and Jammu and Kashmir show an impressive decline in the extent of gender biased sex selection though in both of these states, the level continues to be well above the national average.

The number of missing female births is very high in Uttar Pradesh, Maharashtra, Gujarat, Rajasthan, Haryana and Madhya Pradesh

Excess female under-five mortality is of the order of 1.4 percent of female births nationally and in the range of 0.5 to 2.5 percent for the large states for which data have been examined. The degree is relatively high in Rajasthan and Uttar Pradesh and low in Himachal Pradesh, Kerala, Tamil Nadu, Maharashtra, West Bengal, Delhi, Jammu and Kashmir, and Uttarakhand. Overall, the inter-state variation in the level of post-natal discrimination is much less than in the level of pre-natal discrimination. There is no evidence that these two levels are correlated; thus, the degrees of pre-natal and post-natal discriminations do not seem to be related empirically.

5 Sex Ratio at Birth by Birth Order

If there is gender biased sex selection, one would expect it to take place after the first child is born, and thus affect SRB at births of higher orders. To see if this is the case in India, SRB estimates were obtained by birth order. It is possible to do so from the NFHS since the survey had obtained fertility histories from women in childbearing ages and the entire sequence of births was recorded. Estimates of the SRB from the NFHS-3 and NFHS-4 were first obtained by five-year periods. As has been noted earlier, estimates for periods much earlier than the survey date are possibly affected by selective omission of daughters and hence only the two recent five-year periods during which all the states were covered were used. These are: 1995-1999 and 2000-2004 from NFHS-3 and 2005-2009 and 2010-2014 from the NFHS-4.

The SRB has been estimated only for the first three orders since in the samples the numbers of births at higher orders are small and the estimates would have relatively large sampling errors. The NFHS-3 data files contained information on 58,128 births during 1995-99 of which 41,903 were of the first three orders and 52,892 births during 2000-04 of which 39,870 were of the first three orders. The NFHS-4 data files contained information on 2,78,146 births during 2005-09 of which 2,17,327 were of the first three orders and 2,63,508 births during 2010-14 of which 2,18,834 were of the first three orders.

The SRB has been estimated only for the first three orders since in the samples the numbers of births at higher orders are small and the estimates would have relatively large sampling errors

Further, since the sampling errors for state level estimates are large, estimates are obtained for groups of states in six regions. The regionalization followed in the NFHS-4 report (IIPS and ICF, 2017) has been adopted here. The regions are:

Northern: Jammu and Kashmir and Ladakh, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Delhi, Rajasthan, and *Chandigarh*;
Western: Gujarat, Maharashtra, Goa, *Diu and Daman, Dadra and Nagar Haveli*;
Central: Uttar Pradesh, Chhattisgarh, Madhya Pradesh;
Eastern: Bihar, Jharkhand, Odisha, West Bengal;
Northeastern: Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam;
Southern: Andhra Pradesh, Telangana, Karnataka, Kerala, Tamil Nadu, *Lakshdweep, Puducherry, Andaman and Nicobar Islands*.

Six union territories, shown in italics, were not included in NFHS-3. Sample weights have been applied.

The results are presented in Table 6. It is seen that at the national level, the SRB is more masculine than the natural level (that is, significantly below 950) at the second order in three periods and at the third order in all the periods. In the northern region, the SRB is highly masculine at the second order and very highly masculine at the third order. Besides, the SRB at the first order is also highly masculine in the northern region since 2000 indicating some selection even at the first birth. The SRB in the western region is also very highly masculine at the

third order. The eastern and central regions have moderately masculine SRB at the second and third orders in the recent years. In the southern region, higher masculinity is seen at the third order in some periods. On the other hand, the northeastern region shows no such pattern.

Overall, there is clear evidence that disparities in the SRB across regions increase with the birth order: the SRB is more masculine than the natural level at the third and second orders. This is prominently so in the northern and western regions and to a lesser extent in the central, southern, and eastern regions. Essentially, the observations on the regional pattern made earlier are reinforced from the tabulations by birth order.

The SRB is more masculine than the natural level at the third and second orders.

Table 6: Sex Ratio Birth by birth order and time periods, India and Regions, NFHS-3 and NFHS-4

(female births per 1000 male births)

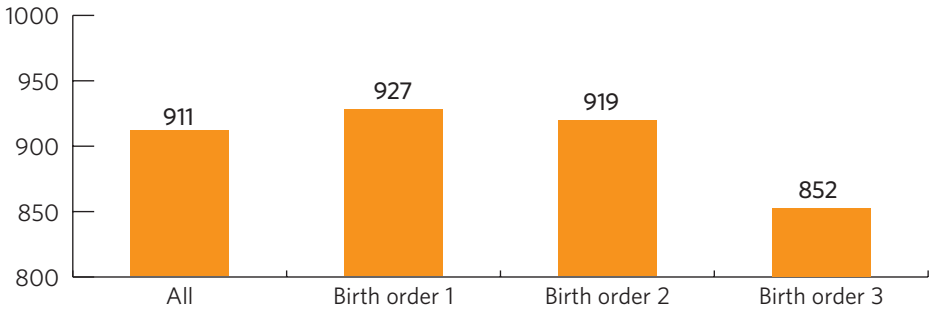
Region	NFHS-3 1995-99				NFHS-3 2000-2004			
	Birth Order				Birth order			
	1	2	3	All	1	2	3	All
Northern	999	863*	844*	894*	871*	861*	779*	842*
Western	979	901	887	926	907	834*	818	877*
Central	1018	926	982	948	972	945	928	935
Eastern	1017	848*	868	937	934	954	978	941
Northeastern	890	980	1009	952	1062	924	923	975
Southern	948	923	797*	914	969	959	810*	935
INDIA	988	898*	894*	930*	942	921	887*	918*

Region	NFHS-4 2005-2009				NFHS-4 2010-2014			
	Birth order				Birth order			
	1	2	3	All	1	2	3	All
Northern	864*	866*	828*	859*	888*	882*	743*	863*
Western	946	917	707*	896*	945	902	767*	899*
Central	961	910*	909*	922*	926	894*	873*	906*
Eastern	979	939	894*	937	953	932	907*	936
Northeastern	926	1039	936	966	904*	959	925	917*
Southern	916	961	985	943	916	959	873*	924*
INDIA	937	926*	877*	919*	927*	919*	852*	911*

**: SRB is lower than 952 female births per 1000 male births at the 1 % level of significance.*
For composition of Regions, see text.
Source: Computed from NFHS-3 and NFHS-4 data files.

Fig. 3: SRB by birth order, NFHS-4, India, 2010-14

(Female births per 1000 male births)
Source: Table 6



6 Conditional Sex Ratio at Birth

The rise in the masculinity of the SRB in India is attributed to son preference and gender biased sex selection in order to avoid the birth of a girl, often called 'daughter avoidance'. In the context of low family size desires, for various reasons including quality-quantity trade-off and government policies, son preference could lead to sex selection rather than continuing childbearing until the desired number of sons are born; this effect is called 'fertility squeeze' or 'intensification' (Das Gupta and Bhat, 1997; Guilmoto, 2009; Bhalla et al., 2013). Correspondingly, the overarching factor for sex selection at the second order birth is the sex of the surviving first child and at higher order births, the sex composition of surviving children. In other words, the decisions on sex selection are likely to be sequential depending on the sex of children already born and such behavior may be manifest after the first birth. If the first birth is a girl, there is likelihood of adopting sex selection and this would then result in fewer daughters at the second birth but such a tendency would be less likely if the first child is a son. Similarly, the SRB at the third birth would be more masculine if the first two children were girls.

The NFHS had collected detailed fertility histories and from these conditional SRB, that is, SRB conditioned on the sex composition of previous children, can be computed. This has been done from the data of the latest two rounds, NFHS-3 and NFHS-4. First, SRB at the second birth has been computed for those whose first child was a son and those whose first child was a daughter. Further, given that the SRB at the third order shows large deviations from the natural range as seen above, SRB at the third birth has been computed by sex composition of the first two births. It must be noted that child loss could influence such decisions. Besides, in case twins are born, there is no sequential decision making at that stage. Therefore, in computing SRBs, twin births and those after a child loss are not taken into account. Sample weights have been applied. The tabulations are made for India and regions but not states since the numbers of births by sex of the first birth and by sex compositions of previous children are small at the state level. Further, the denominators for many of the categories of sex composition of previous children are small in the NFHS-3 even at the level of region and hence only the estimates at the national level are presented from the NFHS-3 data set. The results are shown in Table 7.

the SRB at the second birth when the first child is a daughter is more masculine than that when the first child is a son and significantly lower than 952 female births per 1000 male births in all the four time periods

At the national level, the SRB at the second birth when the first child is a daughter is more masculine than that when the first child is a son and significantly lower than 952 female births per 1000 male births in all the four time periods. This is also seen in the northern, western, and central regions in both the periods of NFHS-4 considered, 2005-09 and 2010-14, and in the southern region during 2005-09. Further, the SRB at the third birth following two daughters is significantly more masculine than the natural level in all the periods 1995-99, 2000-2004, 2005-2009, and 2010-14 at the national level. The northern, western, and central regions also show such a pattern during 2005-09 and all the regions show this pattern during 2010-14. In particular,

Table 7: Sex Ratio at Birth by Sex Composition of Previous Births, India and regions

(female births per 1000 male births)

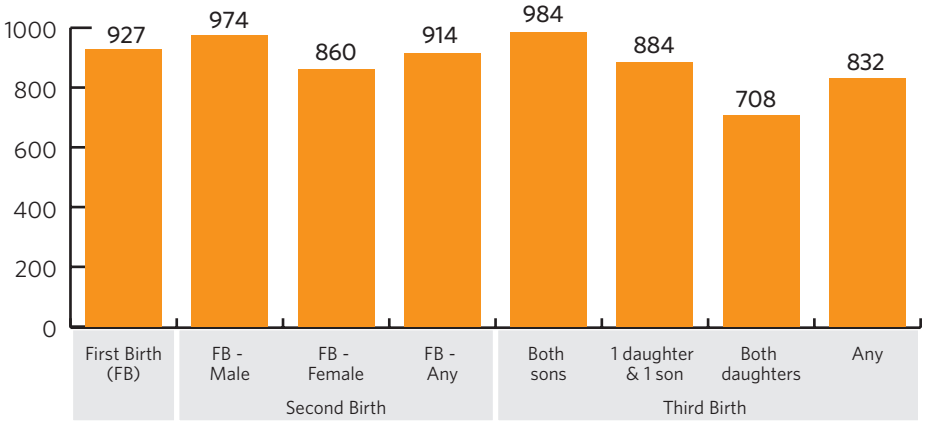
Survey/Region	First Birth	Second Birth			Third Birth			
		Sex of first birth			Sex composition of first two births			
		Male	Female	Any	Both sons	One daughter and one son	Both daughters	Any
NFHS-3 (1995-99) INDIA	979	928	863*	895*	970	860*	798*	866*
NFHS-3 (2000-04) INDIA	941	1003	834*	913*	967	916	812*	894*
NFHS-4 (2005-09)								
Region								
Northern	865*	1015	728*	863*	1004	882*	633*	812*
Western	946	1033	798*	910	918	735	579*	697*
Central	959	970	840*	904*	1004	909	857*	913
Eastern	981	917	959	939	901	905	883	898*
Northeastern	928	1040	1051	1046	971	899	897	915
Southern	917	1032	877*	953	1108	1089	850	998
INDIA	938	990	858*	922*	977	899*	781*	874*
NFHS-4 (2010-14)								
Region								
Northern	888*	999	782*	880*	905	812*	585*	726*
Western	943	1082	775*	909	916	843	572*	721*
Central	927	929	845*	886*	956	897	766*	863*
Eastern	953	916	917	917	1081	930	760*	895*
Northeastern	902*	1020	904	959	905	981	822*	912
Southern	917	1001	919	960	986	834	788*	845*
INDIA	927*	974	860*	914*	984	884*	708*	832*

Note: Twins and those with the previous birth/births not surviving are excluded.
**: SRB is lower than 952 female births per 1000 male births at the 1 % level of significance.*
For composition of Regions, see text.
Source: Computed from NFHS-3 and NFHS-4 data files.

Fig. 4: Conditional SRB by sex composition of previous births, NFHS-4, India, 2010-14

(Female births per 1000 male births)

Source: Table 6



The SRB at the third birth after two daughters is extremely low in the northern and western regions. Moreover, the SRB following one daughter and one son is also more masculine than the natural level at the national level in three time periods. The NFHS-4 data show this phenomenon in the northern region and to a smaller extent in the western region. Thus, sex selection at the third birth when the first two children are daughters seems widely prevalent and this is of a high degree in the northern and western regions in which sex selection is also seen to be prevalent at the second birth.

These results are in broad agreement with the findings based on two other national surveys, the Special Fertility and Mortality Survey of 1998, and the India Human Development Survey (IHDS)-1, as well as from an earlier analysis of the NFHS (see, Jha et al., 2006; Desai et al., 2010, and Jha et al., 2011).

Differentials in Sex Ratio at Birth

7

Guilmoto (2009), drawing upon Coale's preconditions for fertility decline, states: "We adapt these prerequisites to sex selection by saying that parents have to be able, willing, and ready to practice sex selection" (p. 526). Various socioeconomic factors have a bearing on the ability, willingness, and readiness to resort to sex selection. Place of residence (rural-urban) has implications for access to the technology since sonographic scan centres are mostly located in urban areas. Besides, place of residence may also plausibly impact sex differential in the perceived value of children. Education and income or wealth level may also influence access to technology (via awareness and affordability) as well as value of children. Strictures and tenets of religion impact desirability of sons as also acceptability of abortion. Social background such as caste or tribe membership may also have a bearing on relative values of sons and daughters and thus on son preference or daughter avoidance. Media exposure brings in awareness of technology and also change in attitudes on gender issues. Values and disvalues of sons vis-à-vis daughters and social pressures to have sons may also vary regionally.

"We adapt these prerequisites to sex selection by saying that parents have to be able, willing, and ready to practise sex selection"

Ideally, the effect of the background factors on the probability of resorting to gender biased sex selection should be analysed. However, gender biased sex selection is illegal in most countries and hence not recorded and couples too may not report these in surveys due to the illegality and social disapproval. But if the SRB is more masculine than the natural level, the implication is that gender biased sex selection does take place. Therefore, instead of differentials in the probability of gender biased sex selection, one can examine differentials in the SRB. Such an analysis is possible if data on fertility histories or birth sequences are available.

7.1 Prior work for India

For India, researchers have examined influences of several factors on the SRB or on the probability of a birth being male on the basis of the data from the National Family Health Surveys (NFHSs) and other large surveys (Retherford and Roy, 2003; Jha et al., 2006; Bhat and Zavier, 2007; Arokiasamy and Goli, 2012). The NFHS collects complete fertility histories and these data can be used to estimate SRB at various birth orders and by sex composition of previous children. Retherford and Roy (2003) analysed data from the fertility histories from the NFHS-1 (carried out during 1992-93) and NFHS-2 (1998-99) and observed that in NFHS-1, the SRB at the third order births was highly masculine for couples with no living son and in NFHS-2, SRB was highly masculine at both the second and the third orders for couples with no living sons. It was found that there are notable regional variations, with states in the western region showing highly masculine SRB in NFHS-1 and NFHS-2, more prominently in NFHS-2. Multivariate analysis using logistic regression revealed hardly any influences of socioeconomic factors in NFHS-1, except a positive effect of urban residence, an effect not seen in NFHS-

2, and negative effect of Muslim religion. Analysis of the NFHS-2 data showed that middle school or higher education, religions other than Hindu and Muslim, and media exposure had an effect (higher masculinity) on the SRB at the second and higher order births. Effects of other factors were insignificant or unclear. The paper carried out logistic regression analysis separately for states in four regions, North, West, East and South but hardly any significant net effects were seen in these state level analyses.

Bhat and Zavier (2007) also analysed data from the NFHS-1 and NFHS-2. They first examined determinants of the use of pre-natal diagnostic technologies based on the NFHS-2 which had enquired about the use of such technologies for births during the three-year period before the survey. The results of logistic regression analysis showed that a number of socioeconomic factors do influence the use of such technologies. However, though use of pre-natal diagnostic technology is a prerequisite for sex selection, as it can be used to detect the sex of the fetus, it is not necessarily used for that purpose. Therefore, use of pre-natal diagnostic technology as such need not necessarily imply gender biased sex selection. Besides, those using such a technology for sex selection may not reveal it in surveys. The paper also examined determinants of the probability of a male birth, using data from the NFHS-1 and NFHS-2. This was found to be significantly high in the north-western and the north-central regions. Socioeconomic factors showed hardly any significant effects. However, the probability of a male birth was significantly high in case of no surviving male sibling before the birth. The probability was lower in case of a high ideal family size. Maternal factors such as age, anemia status, use of pre--natal care, birth attendance, body-mass index were also used in this analysis but it was also noted that there are issues of measurement in respect of these variables.

The SRB at the third order births was highly masculine if the first two children were female

Jha et al. (2006) analysed data from the Special Fertility and Mortality Survey (SFMS), a very large survey with a sample size of 1.1 million households (in contrast to about 100 thousand in the NFHS-1 and NFHS-2) and covered 133738 births which occurred during 1997. This too found that the SRB at the second order births was very highly masculine in case the first child was female. Similarly, the SRB at the third order births was highly masculine if the first two children were female. Among socioeconomic variables, mother's education had a positive effect on the probability of a male birth but religion and size of agricultural land owned did not show a significant effect. At the third order births for those with no living sons, urban residence had a significant positive effect. Arokiasamy and Goli (2012) focused on the rural population and on the basis of the NFHS-3 data (2012) noted a positive effect of the size of landholding on the probability of a male birth after one or two daughters. Wealth index also showed a positive influence prominently at the second birth whereas maternal education and caste did not show a clear effect in their study.

7.2 Analysis based on NFHS-4

The studies cited above used data referring to the 1990s and early 2000s. Over time, there have been many changes; the technology has become more widely available with the spread of pre-natal scan facilities (for the purpose of pregnancy care rather than for sex selection per se), the laws prohibiting sex detection have been strengthened (the amended PCPNDT Act) in India, there have been campaigns both by the government and by civil and religious organisations against sex selection, and socioeconomic changes have been taking place which could plausibly change family size desires, relative values of sons and daughters, and gender attitudes.

Therefore, this study examines the influences of socioeconomic factors on sex selection indirectly via the probability of a male birth on the basis of the data from the latest round of the NFHS (NFHS-4) which was conducted during 2015-16 throughout India. The sample size of the NFHS-4 was quite large, much larger than the size in the earlier rounds, and thus the NFHS-4 provides recent data that too from a large sample. The results from this analysis are presented below.

The SRB is lower for the richest wealth index group compared to the poorest

7.2.1 Gross differentials

The SRB at the first birth is computed by categories of selected background characteristics: Place of residence (Rural, Urban), Education of mother (No education, Primary, Secondary, Higher), Wealth index quintiles (Poorest, Poorer, Middle, Richer, Richest), Religion (Hindu, Muslim, Other religions), Social Group (Scheduled Caste-SC, Scheduled Tribe-ST, Other Backward Caste-OBC, Others labelled as Non SC/ST/OBC), Exposure to mass media (No or low, Moderate, High) and Region (Central, Southern, Western, Northern, Eastern, Northeastern). The regionalization is in accordance with that in the NFHS-4 as noted earlier in section 5.

The wealth index has been constructed in the NFHS on the basis of household ownership of assets and housing conditions and quintile groups have been provided in the NFHS data sets. Exposure to mass media has been ascertained based on responses to NFHS questions on whether the respondent reads newspapers or watches television; those who do not read newspaper/watch television at all or do so less than once a week are categorised as having 'No or low exposure', those who read newspapers/watch television at least weekly but not daily as having 'Moderate exposure', and those who read newspaper/watch television daily as having 'High exposure'.

The analysis has been done separately for two five-year time periods, 2005-2009 and 2010-2014. Estimates for the two time periods allow one to see if the pattern has changed over time. Similarly, SRB at the second birth has been computed by the background variables separately for those with the first birth a son and those with the first birth a daughter. Further, only those births where the first child was surviving are included since it is the sex composition of the number of living children that matters in sex selection. The SRB at the third birth has been computed by the sex composition of the first two births: two sons, one son and one daughter, and two daughters and only those third births where the first two children survived have been included. Twins have been excluded in the computation of the SRB. Since the number of births beyond the third order was small, SRB has been computed only for the first three orders. Sample weights have been applied.

Table 8 presents the SRBs at the first birth by backgrounds characteristics (the table also shows results of logistic regression analysis which are discussed later, in the next sub-section). The SRB in the urban population is lower than the rural population and significantly lower than 952 in the periods 2005-2009, and 2010-2014. Differentials by education of mother do not show a pattern. The SRB is lower for the richest wealth index group compared to the poorest. Differentials by religion and social group do not show a clear pattern. The northern region shows lower SRB than other regions in both the periods. The SRB is significantly lower than 952 at high media exposure only in the recent period.

As seen in Table 7, if the first birth is a son, the SRB at the second birth does not show lower than natural SRB in any of the regions. Hence, results of further analysis in this case have not been presented here. If the first child is a daughter,

the SRB at the second birth is significantly lower than 952 in both rural and urban areas, among births to women with secondary and higher education, and from upper quintiles of wealth index (Table 9). The SRB for births to women belonging to religions except Muslim, and those not belonging to SC and ST categories is also low. The northern, western, and central regions also have low SRB; it is very low in the northern region. The SRB is also low for those with high media exposure. Some categories show a low SRB in one of the two periods. Overall, there is clear evidence of sex selection at the second birth if the first child is a daughter and this is seen at the national level, in some regions, prominently the northern, and in socially or economically advantaged classes. On the other hand, among Muslims, there is absence of sex selection at this stage.

Table 8: Sex Ratio at First Birth and Adjusted Sex Ratios by Background Characteristics, India, NFHS-4

(SRB is expressed as female births per 1000 male births)

Characteristic	Period	2010-14			2005-09		
	Categories	SRB	Adjusted SRB	ODDS RATIO	SRB	Adjsuted SRB	ODDS RATIO
Place of residence	Rural ®	935	931	1	947	940	1
	Urban	910*	918	1.01	919	933	1.01
Education of woman	No education ®	959	950	1	917	897	1
	Primary Secondary	901	893	1.06	991	981	0.91@
	Higher	919*	918	1.03	939	946	0.95
		936	957	0.99	914	947	0.95
Wealth index quintile	Poorest ®	937	920	1	979	970	1
	Poorer	971	971	0.95	926	921	1.05
	Middle	899*	904	1.02	945	946	1.03
	Richer	936	943	0.98	950	955	1.02
	Richest	895*	896	1.03	889*	898	1.08@
Work status of woman	Did not work ®	927	927	1	941	942	1
	Worked	939	931	1.00	872	869	1.08
Religion	Hindu ®	930	929	1.00	943	943	1
	Muslim	917	919	1.01	931	923	1.02
	Other	911	920	1.01	878*	897	1.05
Social group	Non SC/ST/OBC ®	931	938	1	947	953	1
	SC	915	912	1.03	930	927	1.03
	ST	992	985	0.95	965	958	0.99
	OBC	916*	915	1.02	930	928	1.03
Region	Central ®	927	925	1	959	958	1
	Southern	917	925	1.00	917	924	1.04
	Western	943	943	0.98	946	944	1.02
	Northern	888*	895	1.03	865*	877	1.09@
	Eastern	953	947	0.98	981	970	0.99
	Northeastern	903	885	1.05	928	917	1.05
Media exposure	No or low ®	941	925	1	959	947	1
	Moderate	924	919	1.01	933	925	1.02
	High	921*	929	1.00	928	935	1.01
	All	927*			938		

Note: Twin births excluded. Adjusted SRB obtained based on logistic regression analysis.

**: indicates the SRB is significantly lower than 952 at 1 % level of significance.*

®: Reference category.

@: indicates the odds ratio (odds of a birth being male) is different from the reference group at 1 % level of significance.

For those with the first two sons, the SRB at the third birth is not highly masculine (see Table 7). While in some categories the SRB is actually higher than 952, in most cases this is not significantly so. Moreover, a high value of SRB need not be taken to imply sex selection in favour of females since so far no evidence has emerged, from research studies or anecdotal, of the prevalence of such a practice. Hence, further analysis for women with the first two births as sons is not presented here. For those with one daughter and one son, the SRB at the third birth is low in some categories especially in the recent period, 2010-14, but there is no consistent pattern over time and across categories of the background variables examined here (Table 10).

Table 9: Sex Ratio at Second Birth after First Daughter and Adjusted Sex Ratios by Background Characteristics, India, NFHS-4

(SRB is expressed as female births per 1000 male births)

Characteristic	Period	2010-14			2005-09		
	Categories	SRB	Adjusted SRB	ODDS RATIO	SRB	Adjusted SRB	ODDS RATIO
Place of residence	Rural ®	876*	856	1	877*	842	1
	Urban	825*	868	0.99	817*	891	0.95
Education of woman	No education ®	913	878	1	902	838	1
	Primary	902	879	1.00	879	848	0.99
	Secondary	855*	864	1.02	844*	879	0.95
	Higher	719*	777	1.13@	714*	836	1.00
Wealth index quintiles	Poorest ®	912	884	1	972	938	1
	Poorer	921	905	0.98	888	879	1.07
	Middle	876*	870	1.02	892	900	1.04
	Richer	854*	860	1.03	838*	848	1.11
	Richest	727*	770	1.15@	694*	719	1.30@
Work status of woman	Did not work ®	863*	863	1	855*	855	1
	Worked	785*	784	1.10	897*	895	0.96
Religion	Hindu ®	844*	843	1	850*	849	1
	Muslim	970	968	0.87@	923	912	0.93
	Other	831*	859	0.98	810*	844	1.01
Social group	Non-SC/ST/OBC ®	824*	841	1	806*	826	1
	SC	886	881	0.95	918	912	0.91@
	ST	875	871	0.97	856*	818	1.01
	OBC	866*	858	0.98	863*	861	0.96
Region	Central ®	845*	837	1	840*	824	1
	Southern	919	948	0.88@	877	900	0.92@
	Western	775*	791	1.06	798*	825	1.00
	Northern	782*	805	1.04	727*	763	1.08
	Eastern	917	881	0.95	959	912	0.90@
	Northeastern	904	855	0.98	1050	1023	0.81@
Media exposure	No or low ®	910	875	1	966	923	1
	Moderate	917	911	0.96	808*	796	1.16@
	High	827*	844	1.04	814*	835	1.11@
	All	860*			857*		

Note: See footnotes to Table 8.

Only those births with the first child surviving are included.

Table 10: Sex Ratio at Third Birth after One Daughter and One Son and Adjusted Sex Ratios by Background Characteristics, India, NFHS-4

(SRB is expressed as female births per 1000 male births)

Characteristic	Period	2010-14			2005-09		
	Categories	SRB	Adjusted SRB	ODDS RATIO	SRB	Adjusted SRB	ODDS RATIO
Place of residence	Rural®	921	905	1	897*	894	1
	Urban	765*	816	1.11	906	915	0.98
Education of woman	No education®	922	887	1	930	930	1
	Primary	946	940	0.94	859	874	1.06
	Secondary	791*	834	1.06	875	871	1.07
	Higher	994	1160	0.76	762	708	1.31
Wealth index quintile	Poorest®	981	939	1	945	933	1
	Poorer	885	872	1.08	871	867	1.08
	Middle	858	884	1.06	852	857	1.09
	Richer	813*	871	1.08	865	875	1.07
	Richest	676*	722	1.30@	984	1011	0.92
Work status of woman	Did not work®	885*	887	1	902*	901	1
	Worked	863	842	1.05	860	874	1.03
Religion	Hindu®	882*	870	0.00	884*	886	0.00
	Muslim	909	963	0.90	966	956	0.93
	Other	818*	796	1.09	891	902	0.98
Social group	Non SC/ST/OBC®	852	865	1	871	880	1
	SC	901	908	0.95	867	869	1.01
	ST	1011	993	0.87	926	941	0.94
	OBC	858*	853	1.01	922	913	0.96
Region	Central ®	897	886	1	910	905	1
	Southern	835	892	0.99	1091	1116	0.81@
	Western	842	889	1.00	736*	753	1.20@
	Northern	812*	845	1.05	883	885	1.02
	Eastern	930	889	1.00	906	894	1.01
	Northeastern	989	945	0.94	891	887	1.02
Media exposure	No or low ®	945	896	1	914	902	1
	Moderate	895	898	1.00	902	923	0.98
	High	810*	866	1.04	883	890	1.01
	All	884*			899*		

Note: See footnotes to Table 8.

0nly those births with the first two children surviving are included.

For women whose first two children are daughters, the SRB at the third order is highly masculine overall and for most of the categories of background variables (Table 11). The SRB is extremely low in the top two wealth and education categories, in urban population, non-Muslims, social group non- SC/ST/OBC, and the northern and western regions. For the most recent period, 2010-14, the SRB is significantly lower than 952 in all the categories except the religion category Muslim and in the southern and northeastern regions. However, some categories (low education, low wealth, Muslims, scheduled tribes, scheduled castes, eastern, northeastern, and southern regions, and low and moderate media exposure), do not show significantly low SRB during 2005-09. The SRB at this stage (third order birth after two daughters) has become more masculine in the recent years and more pervasive than in the past. Besides, wide differentials persist. Clearly,

strong son preference has led to a high degree of sex selection if the first two children are girls and this is particularly so for some socioeconomic classes and in the northern and western regions.

7.2.2 Multivariate analysis: Net differences

The differentials in SRB noted above are gross differences. Since many of the socioeconomic factors are highly associated leading to possible confounding of effects, it is necessary to assess net influences of various factors. To this end, logistic regression analysis has been carried out with the sex of the birth, male or female, as the dichotomous dependent variable and the socioeconomic and spatial variables listed in the previous sub-section as explanatory variables. The dichotomous dependent variable has a value of 1 for male and 0 for female; thus the analysis examines the net influences of various factors on the probability of a birth being a male, controlling for the effects of other explanatory variables used in the analysis.

There are four regressions: i) for the first birth, ii) for the second birth for those whose first birth was a daughter, iii) for the third birth for those whose first two births included one son and one daughter, and iv) for the third birth for those whose first two births were daughters. Since, as noted above, the SRB at the second birth following one son and at the third birth following two sons was not found to be highly masculine, results for these situations are not presented. Analysis has been carried out for the time periods 2005-2009 and 2010-2014 separately.

For women with two daughters, the SRB at the third birth is significantly lower than 952 in all the categories except the religion category Muslim and in the southern and northeastern regions

Table 11: Sex Ratio at Third Birth after First Two Daughters and Adjusted Sex Ratios by Background Characteristics, India, NFHS-4

(SRB is expressed as female births per 1000 male births)

Characteristic	Period	2010-14			2005-09		
	Categories	SRB	Adjusted SRB	ODDS RATIO	SRB	Adjusted SRB	ODDS RATIO
Place of residence	Rural®	760*	724	1	818*	759	1
	Urban	582*	665	1.09	680*	844	0.90
Education of woman	No education®	820*	759	1	902	805	1
	Primary	733*	706	1.08	834	824	0.98
	Secondary	656*	702	1.08	665*	760	1.06
	Higher	356*	432	1.76@	342*	473	1.70@
Wealth index quintile	Poorest ®	795*	690	1	950	864	1
	Poorer	852	814	0.85@	903	878	0.98
	Middle	706*	730	0.95	776*	802	1.08
	Richer	593*	657	1.05	693*	745	1.16
	Richest	481*	606	1.14	435*	507	1.70@
Works status Of woman	Did not work ®	710*	711	1	792*	793	1
	Worked	673*	645	1.10	623*	612	1.30@
Religion	Hindu ®	690*	680	1	768*	762	1
	Muslim	807	856	0.79@	904	925	0.82@
	Other	700*	745	0.91	625*	674	1.13
Social group	Non SC/ST/OBC®	610*	648	1	642*	697	1
	SC	767*	767	0.85@	827	809	0.86
	ST	807*	780	0.83	966	945	0.74@
	OBC	714*	697	0.93	794*	775	0.90
Region	Central ®	766*	751	1	857	826	1
	Southern	786	862	0.87	850	935	0.88
	Western	573*	616	1.22@	579*	621	1.33@
	Northern	584*	628	1.20@	633*	714	1.16
	Eastern	760*	697	1.08	882	791	1.04
	Northeastern	822	721	1.04	888	813	1.02
Media exposure	No or low ®	841*	784	1	931	837	1
	Moderate	705*	692	1.13	908	897	0.93
	High	618*	657	1.19@	654*	716	1.17@
	All	708*			780*		

Note: See footnotes to Table 8.

Only those births with the first two children surviving are included.

All the explanatory variables are categorized and the reference category in each has been designated. The odds ratio for a specific category shows the ratio of odds of a birth being a male in the specific category to the odds for the reference category. On the basis of the regression coefficients, the predicted value of the probability that a birth is male has been computed for each category of the explanatory variables, holding other variables constant. These are thus adjusted probabilities, adjusted for the effects of other variables, as in Multiple Classification Analysis (MCA). From these probabilities, the corresponding values of adjusted SRB (female births per 1000 male births) for category j of variable i have been computed simply as, Adjusted SRBij = 1000 x (1-Adjusted pij)/Adjusted pij, where Adjusted pij is the adjusted probability of a birth being a male for category j of variable i computed from the coefficients of the logistic regression

equation. Twin births have been excluded in the analysis. Further, only those births where the first child was surviving are included in the analysis of the sex of the second birth and only those births where the first two children were surviving are included in the analysis of the sex of the third birth. Sample weights have been applied.

Table 8 presents the results for the sex of the first birth. The columns show the unadjusted SRB, the adjusted SRB, and the odds ratio for each category. The adjusted SRBs vary somewhat from the unadjusted SRBs but generally the differences are small. Hardly any odds ratios are significant (that is, the logistic regression coefficients for the categories are not significant). This is true of both the time periods 2005-09 and 2010-14. As noted above, gross differentials are also minor and showed no pattern. Thus, the SRB at the first birth does not seem to be notably influenced by any of the background factors.

Analysis for the sex of second birth in case the first is a daughter reveals that the richest wealth category shows lower SRB compared to the poorest in both the periods and the higher education category compared to those with no education during 2010-14 (Table 9). Muslim religion has significantly higher SRB than Hindus during 2010-14. Social groups generally do not show significant net differences except for SCs during 2005-09. Some regions have higher adjusted SRB than the central region (reference category); the southern in both the periods and the eastern and the northeastern in only one period. Overall, socioeconomic differences are not very consistent except the low values for the high education and wealth index groups. Note that the lack of significantly high odds ratios does not imply that the SRB is not higher than the natural. In fact, for the second birth after a daughter, the SRB is highly masculine for most categories.

Analysis for the sex of second birth in case the first is a daughter reveals that the richest wealth category shows lower SRB compared to the poorest in both the periods and the higher education category compared to those with no education during 2010-14

For the third birth after one daughter and one son, the odds ratios by and large do not differ significantly from 1 (Table 10). Thus, the adjusted SRB for most categories does not differ from that for the reference category. There are only a few exceptions, richest category during 2010-14, and the southern and western regions during 2005-09. In contrast, notable differences in adjusted SRB are seen in the case of the SRB at the third birth following two daughters, (Table 11). The odds ratio for the high education category is significantly high in both the time periods and for the richest category in one period. The adjusted SRBs for the top education and wealth categories are higher than the unadjusted SRBs; thus the net effect is not as strong as seen in the gross differentials; yet even the adjusted SRBs are quite low for these categories. On the other hand, the SRB for Muslims is significantly higher than Hindus in both the periods. No clear net differences are seen across social groups. The northern and western regions show significantly lower SRB than the central region (which too shows a low SRB) in one or both periods. The SRB at high media exposure is lower than at no or low level of exposure. The overall SRB at this stage, that is, at the third birth after two daughters, is low (that is, highly masculine), and this is so for the reference categories of all the seven variables in the 2010-14 period and except for those with low levels of education and the poorest, in the 2005-09 period as well. A high value of the odds ratio for any category then implies a very highly masculine SRB even after effects of other factors are adjusted. This is seen from the adjusted SRBs shown in the table.

Overall, as assessed from the SRBs at different stages of family building, sex selection at the first birth does not seem to be at a notable level. There is some indication of this in the northern region and for the richest quintile of the population but the effects seem to become weaker once other factors are controlled.

On the other hand, sex selection is quite conspicuous at the second birth in case the first was female. This cuts across most of the regions and socioeconomic backgrounds. The degree is quite high for the richest quintile and to some extent for the richer quintile as well as for those with higher education but relatively lower for Muslims. There is some sex selection at the third birth in case the first two include a daughter and a son. This is especially seen in the northern region and the richest quintile. But net differences are generally not significant. Sex selection is high at the third birth for those whose first two children were daughters. This is seen regardless of background characteristics and cuts across all the regions in the recent years. Moreover, the northern and western regions, the wealthiest sections of population, and those with higher education show very high degree of sex selection. The relatively higher prevalence of sex selection in higher education as well as wealth/income classes in India could, at least in part, be attributed to the greater awareness of, access to, and affordability of the technology of sex selection for these sections of population. Religious and moral considerations and societal norms may prohibit access to abortion and this is probably the reason for the absence or very low prevalence of sex selection among Muslims.

Why Sex Selection?

8

The prime motive for resorting to sex selection, specifically of a male, is a strong preference for sons over daughters. Son preference is known to be widely prevalent around the world (Williamson, 1976) and especially in parts of Asia (Das Gupta et al. 2003). Many couples would like the family line to continue and in patrilineal societies male offspring are needed for this purpose. Besides, certain rituals, especially those related to death (burial or lighting the funeral pyre) and ancestor worship are traditionally performed by sons. Such values may be considered sentimental or ritual. For more practical and material needs such as old age security, traditionally sons are valued over daughters. This may involve residence during old age, especially when the couple can no longer work or take care of day-to-day household management, as well as financial support. In patrilocal (or virilocal) arrangements, sons and their families are expected to reside with parents whereas a married daughter would reside with the parents of her husband. Children also contribute to family labour (labelled as 'production utility' by Leibenstein, 1974) and for many agricultural operations and enterprises sons are valued over daughters though daughters do contribute to household work and also to agricultural and similar activities. However, over time, the extent of child labour has declined and the labour value of children is no longer a major issue. Expenses on marriages of daughters, especially dowry and costs of the celebration, if expected to be borne by the family of the bride, lead to 'disvalues' of daughters. Another factor is the consideration of security of unmarried daughters and apprehensions on safety of unmarried girls could lead to 'daughter aversion'. Overall, for various reasons, the perceived value of sons differs from that of daughters. The degree of son preference depends on how high is the perceived value of sons vis-à-vis daughters. Such values may vary across social, cultural, and economic settings.

8.1 Evidence on values of sons vis-à-vis daughters in India

There is a huge body of literature on perceived values of a daughter vis-à-vis a son in India. Kaur and Kapur (2018) provide a comprehensive review of the studies with focus on recent changes in various aspects, namely, education, marriage, work, rituals, and property. A field investigation in five states examined factors that lead to son preference (John et al, 2008). In a more recent study in Haryana and Maharashtra, John (2018) adopted a qualitative approach to inquire into recent changes in attitudes towards daughters and sons. Further, three studies commissioned by the UNFPA in Tamil Nadu, Maharashtra, and Punjab also addressed these issues as perceived by 'daughters only' families following qualitative methods (Gokhale Institute of Politics and Economics, 2017). These studies do show that attitudes have changed in the recent years. There is now a strong desire among couples to educate daughters. Though the level of education desired for daughters may not be as high as that desired for sons, often at least high school education and in many cases higher education is sought

Though daughters are legally entitled to inherit family property including land, generally many women forgo their share in ancestral property and let brothers have it

for daughters. This is in order to enable daughters to seek employment in the modern sector (so that they are self reliant and can 'stand on their feet') and also to improve prospects of finding a good groom. The need of a son for continuing lineage and for rituals including funeral and ancestor worship seems to be not as strong as in the past and there is some acceptance of daughters performing such rituals. Though daughters are legally entitled to inherit family property including land, generally many women forgo their share in ancestral property and let brothers have it. It is understood that daughters would get some share at the time of marriage in a form other than the family house or land and hence would not exercise right to parental property later. In case of a couple with no sons, a daughter inherits the property if her husband moves in with her parents (the husband is then called 'ghar jamai') and thus the daughter's husband and children reside with her parents. But parents generally do not prefer to move to the daughter's marital home. Financial support from daughters is generally not expected. However, many 'daughters only' couples noted that sons too may not provide support as they may get into 'undesirable habits' and cannot be relied upon. While this could be post-facto attitude or rationalization, complaints of young men getting into drinking or drug use are common. Though the marriage of a daughter involves expenses including dowry, the groom's family also has to incur expenditures and heavy costs of performing a daughter's marriage did not figure as a notable factor causing daughter avoidance in responses of participants of these studies.

In addition to the qualitative studies, the India Human Development Survey-II, carried out during 2011-12 in India (IHDS, 2018), also collected information on old age security expectations from children. The survey covered 42152 households and 39253 ever married women of reproductive ages were interviewed. In the survey, married women were asked a series of questions on expectations of old age security and from the responses one can see whether the degree of dependence on sons vis-à-vis daughters varies across background characteristics and regions. The women were asked: 17.41: Who do you expect to live with when you get old?: 'Son', 'Daughter', 'Both', and 'Others' were listed as responses. Those whose response did not include 'Daughter' were further asked: 17.42 Would you consider living with your daughter? Similar questions were asked on financial support during old age: 17.43 Who do you expect will support you financially when you get older? And again those whose response did not include 'Daughter' were asked: 17.44: Would you consider being financially supported by your daughter? In the case of living arrangements, those whose first response (Q.17.41) did not include 'Daughter' were subdivided into 'Sons only' (response as 'Son' to Q.17.41 and 'No' to Q.17.42) and 'Son or Daughter' (Response 'Son' to 17.41 and 'Yes' to 17.41). Similarly, the categories 'Others only' and 'Others or daughter' were created. In a like manner, responses to questions on financial support during old age were categorized.

The responses are tabulated by key background characteristics in order to see if perceived values vary by socioeconomic background. The characteristics used are: place of residence (rural/urban), educational level of woman (no, primary, secondary, higher), per capita income quintiles (poorest, poorer, middle, richer, and richest), working status of woman (Yes: working, No: not working), religion (Hindu, Muslim, other), social group (SC, ST, OBC, and Non-SC/ST/OBC), and ownership of agricultural land by the household (No, Yes). Besides, tabulations are also made by region, for the six regions as in tables based on NFHS presented earlier. Further, the tabulations by region are also provided separately for those with no living son and those with at least one living son in order to see what the expectations of those without a son are. Sample weights have been applied.

It is seen from Table 12 that a majority of women, 65 percent, expect to live only with sons in old age in contrast to less than 10 percent expecting to live with daughters. This is to be expected given the patrilineal and patrilocal traditions in most of the country (some communities in parts of the northeast and the south-western coast do not follow patrilocal traditions and, according to tabulations by states, not shown here, 86 percent of women in Meghalaya expect to live with daughters in old age). Variations by socio-economic background factors are not so conspicuous except that reliance on sons is slightly higher than average among non-SC/ST/OBC women. No differentials are seen by place of residence (rural-urban) and by ownership of agricultural land. The expectation to live with sons is higher than the national average in the western and northern regions and lower in the southern region. Separate tabulations by the number of sons at the time of the survey show that even among those with no sons at the time of survey, about 25 percent mentioned that they expect to live only with sons (shown in the lower panels of the table); this percentage is higher, over 40 percent, in the western and northern regions.

For financial support during old age, a majority of women (57 percent) expect to rely only on sons (Table 13). Again, this level is high in the western and northern regions than in the other regions. Such exclusive reliance on sons is the least in the northeastern region and lower than average in the southern (in Meghalaya, reliance exclusively on sons is only 11 percent). Differentials by socioeconomic factors are narrow. Among those with no sons at the time of survey, about a fifth expected financial support only from sons.

Table 12: Expected living arrangements in old age by background characteristics, ever married women of ages 15-49, India, IHDS-II

Characteristic	Category	(Percent who expect to live with)						
		Sons only	Daughters	Both S & D	Others only	Son or Daughter	Others or daughter	Total
Place of residence								
	Rural	65.0	7.3	5.3	4.0	18.0	0.5	100
	Urban	65.3	9.0	4.8	4.3	16.3	0.4	100
Education level completed								
	No	65.0	6.1	4.9	2.9	20.9	0.3	100
	Primary	67.2	7.3	5.1	4.5	15.1	0.7	100
	Secondary	65.0	9.2	5.4	4.8	15.2	0.5	100
	Higher	60.3	12.2	5.3	7.0	14.9	0.3	100
Per capita income quintiles								
	Poorest	63.3	6.8	5.5	3.6	20.4	0.4	100
	Poorer	64.2	7.3	5.2	3.9	19.1	0.3	100
	Middle	65.4	8.0	5.8	3.9	16.6	0.3	100
	Richer	66.0	8.4	4.7	4.3	16.3	0.3	100
	Richest	66.6	8.7	4.7	4.7	14.5	0.8	100
Working presently								
	No	66.1	7.0	5.4	4.3	16.8	0.5	100
	Yes	63.6	9.0	4.9	3.8	18.3	0.4	100
Religion								
	Hindu	65.7	7.7	4.7	4.2	17.4	0.4	100
	Muslim	63.1	6.9	7.4	4.1	18.1	0.3	100
	Other religions	58.5	11.8	8.0	2.8	16.8	2.0	100
Social group								
	Non SC/ST/OBC	70.0	6.6	4.7	4.3	13.9	0.5	100
	OBC	62.9	8.3	4.8	3.6	20.2	0.3	100
	SC	65.0	7.8	5.2	4.5	16.9	0.5	100
	ST	60.3	9.3	8.8	4.8	16.2	0.6	100
Own agricultural land								
	No	64.6	9.1	5.1	4.1	16.7	0.4	100
	Yes	65.6	6.4	5.2	4.1	18.2	0.4	100
All		65.1	7.8	5.2	4.1	17.4	0.4	100
Region	Central	63.6	5.9	5.7	5.0	19.8	0.1	100
	Southern	53.3	16.9	5.5	3.2	20.4	0.7	100
	Western	81.7	3.4	2.1	3.0	9.0	0.8	100
	Northern	72.5	3.3	3.0	3.3	17.6	0.3	100
	Eastern	63.3	5.5	5.7	5.7	19.6	0.3	100
	Northeastern	60.8	13.8	19.7	2.4	2.7	0.7	100
	All	65.1	7.8	5.2	4.1	17.4	0.4	100
Among those with no living son								
Region	Central	20.9	37.0	8.6	23.8	9.2	0.4	100
	Southern	10.0	66.1	3.9	11.2	6.4	2.4	100
	Western	47.2	20.9	2.6	17.5	6.8	5.0	100
	Northern	42.4	24.1	5.3	14.2	12.3	1.8	100
	Eastern	26.7	29.7	10.0	19.8	12.1	1.7	100
	Northeastern	22.8	43.6	18.1	10.0	2.7	2.7	100
	All	24.7	41.0	6.7	16.7	8.7	2.2	100
Among those with at least one living son								
Region	Central	72.3	0.2	5.1	0.5	21.9	0.0	100
	Southern	66.3	2.3	6.0	0.6	24.7	0.1	100
	Western	87.8	0.3	2.0	0.3	9.5	0.1	100
	Northern	77.1	0.2	2.6	1.5	18.4	0.1	100
	Eastern	70.7	0.6	4.8	2.8	21.1	0.0	100
	Northeastern	71.5	5.3	20.1	0.2	2.7	0.1	100
	All	73.7	0.9	4.8	1.2	19.3	0.1	100

Source: Computed from IHDS-II data files.

Table 13: Expected financial support in old age by background characteristics, ever married women of ages 15-49, India, IHDS-II

Characteristic / Category	(Percent who expect support from)						
	Sons only	Daughters	Both S & D	Others only	Son or Daughter	Others or daughter	Total
Place of residence							
Rural	56.6	7.5	8.2	7.5	19.4	0.8	100
Urban	57.8	9.3	7.1	8.2	16.6	0.9	100
Education level completed							
No	57.9	6.3	8.0	5.5	21.6	0.6	100
Primary	58.3	7.8	7.9	8.0	17.3	0.7	100
Secondary	56.6	9.3	7.8	9.0	16.4	1.0	100
Higher	49.5	12.4	7.7	13.0	15.5	1.9	100
Per capita income quintiles							
Poorest	55.7	7.1	8.5	6.6	21.3	0.7	100
Poorer	56.3	7.0	8.7	7.1	19.7	1.1	100
Middle	56.4	8.4	8.2	7.6	18.5	0.9	100
Richer	58.0	8.6	7.1	8.2	17.6	0.6	100
Richest	58.3	9.3	6.8	9.2	15.5	0.9	100
Working presently							
No	57.5	7.3	8.2	8.5	17.5	0.9	100
Yes	56.0	9.2	7.4	6.6	20.0	0.7	100
Religion							
Hindu	57.8	8.0	7.0	7.8	18.6	0.8	100
Muslim	54.8	6.4	11.5	7.7	18.6	1.0	100
Other religions	48.3	13.4	13.3	6.6	17.2	1.1	100
Social group							
Non SC/ST/OBC	60.4	7.5	7.3	8.4	15.4	1.1	100
OBC	55.8	8.1	7.1	7.1	21.2	0.6	100
SC	56.6	8.6	8.2	7.7	18.0	0.9	100
ST	52.3	8.5	13.0	8.7	16.6	0.9	100
Own agricultural land							
No	56.8	9.3	7.6	8.0	17.4	0.9	100
Yes	57.0	6.7	8.2	7.4	19.8	0.8	100
All	56.9	8.1	7.9	7.7	18.5	0.8	100
Region							
Central	56.2	6.0	9.2	6.4	22.0	0.2	100
Southern	46.1	16.6	8.0	7.6	20.9	0.8	100
Western	75.9	5.3	3.2	5.8	9.2	0.5	100
Northern	65.0	3.6	4.8	7.0	18.7	0.8	100
Eastern	54.4	5.9	7.7	10.7	20.1	1.2	100
Northeastern	31.5	11.5	32.3	9.2	11.0	4.5	100
All	56.9	8.1	7.9	7.7	18.5	0.8	100
Among those with no living son							
Region							
Central	18.3	33.0	9.6	29.5	8.5	1.0	100
Southern	8.5	56.7	5.6	21.6	5.2	2.5	100
Western	38.8	23.2	4.8	26.0	4.6	2.6	100
Northern	29.4	17.6	7.0	29.5	12.5	4.0	100
Eastern	18.9	24.0	9.8	32.6	9.5	5.2	100
Northeastern	9.7	36.9	19.6	21.3	4.3	8.2	100
All	19.5	34.4	8.1	27.2	7.6	3.3	
Among those with at least one living son							
Region							
Central	65.1	0.4	9.1	0.4	25.1	0.0	100
Southern	58.9	3.1	8.9	2.7	26.2	0.2	100
Western	84.6	1.2	2.8	0.9	10.3	0.1	100
Northern	72.4	0.7	4.4	2.3	20.1	0.2	100
Eastern	64.3	0.9	7.1	4.5	23.1	0.1	100
Northeastern	39.6	2.3	36.9	4.6	13.5	3.1	100
All	66.9	1.3	7.8	2.3	21.5	0.2	100

Source: Computed from IHDS-II data files.

It is customary to give some gold in the form of jewelry to the bride. Dowry in cash is also given though this is less prevalent in the northeastern and northern regions and the amounts are relatively higher in the southern region

A factor mentioned in the context of daughter aversion is the perceived harassment of unmarried daughters in the neighborhood. The IHDS had asked a question: How frequently are unmarried girls harassed in your village/neighborhood?; the responses were: 'Rarely', 'Sometimes', and 'Often'. Less than 10 percent of women reported that this occurs often in their village or neighbourhood. The qualitative studies cited above also revealed that while couples are aware of such harassment, many said that they heard of such incidences through the media or occurrences at other places. Daughter avoidance due to this factor does not appear to be a major factor.

The IHDS also collected data on marriage expenses including gifts and dowry at the time of marriage as prevalent in the community. It is customary to give some gold in the form of Jewellery to the bride. Dowry in cash is also given though this is less prevalent in the northeastern and northern regions and the amounts are relatively higher in the southern region. Overall wedding expenses are higher for the bride's family but the groom's family also incurs expenditures; the ratio of the median expenditure by brides' family to that by the groom's family is in the range 1 to 2.

If daughters inherit parental property to the same extent as sons, many women should be owners of property such as a house or land. In the NFHS-4, women were asked questions on ownership of house or land. It is seen that about two thirds of the married women interviewed in the survey did not own a house either individually or jointly (in the NFHS-4 these questions were asked only to married women in a sub-sample, the state module, of the main sample, and covered 121118 women). Hardly any differentials by socioeconomic factors are seen (Table 14) but the northern and western regions show lower levels of ownership by women compared to the other regions. Similarly, over 70 percent of women did not own any land individually or jointly. The level of 'non-ownership' of land is higher in the western and northern regions and lower in the northeastern region than average. Separate tabulations for the rural population (for which ownership of land matters more than for the urban population) give a fairly similar picture though, as expected, the non-ownership of land is lower in the rural population than urban, yet substantial, 69 percent. Given that inheritance laws entitle daughters to have a share in ancestral property, ownership of women is insisted upon in certain housing schemes and land allotments, and further that there are incentives for female ownership such as lower stamp duties in some states, the level of female ownership appears to be quite low.

Fertility surveys generally ask direct questions on ideal number of children and note these by sex. Results on this from the NFHS-4 show a mild preference for sons; at the national level, the mean ideal number of sons was 1.1 compared to 0.9 daughters (IIPS and ICF, 2017: Table 4.16, p.104). Further, 18.8 percent of interviewed women stated more sons than daughters in the ideal combination; this is lower than the figure in the NFHS-3, 22.4 percent, and shows some decline over time in the degree of son preference. But the percentage who mentioned more sons than daughters is relatively higher for women with no schooling and the lowest wealth index quintile than those with higher levels of education and wealth quintiles respectively whereas the degree of sex selection, as seen from the SRB, is higher for those with higher education and wealth levels. Further, most of the states in the northern and western regions which have exhibited high sex selection in our analysis show lower son preference and many states in the eastern and northeastern region show higher son preference in response to the question on ideal number of sons and daughters (see Table 4.17 in IIPS and ICF, 2017). Of course, one does not expect a perfect correspondence between

son preference and sex selection since the willingness and ability to practise sex selection also matter. But it is quite likely that there is a tendency to give normative and socially and politically correct responses to the question on ideal number of children by sex and hence one may not see agreement between the responses to direct questions on son preference and degree of sex selection as ascertained from the analysis of data on SRB.

The NFHS also asked married women whether they want any more children and these responses are tabulated in the NFHS reports by the number of living children as well as by the number of living sons. For India, among women with two children, 87 percent of those with one son (that is, those with one son and one daughter) did not want any more children in contrast to 62 percent of those with no son, that is, those with only two daughters (see Table 4.14 in IIPS and ICF, 2017). The fact that 62 percent of women with no son wanted to stop childbearing shows that a majority does not insist on a son, yet the difference between the two percentages is conspicuous and shows that many desire to have at least one son. The gap between the two percentages is very wide in many states in the northern region, around 50 percentage points in Haryana and Rajasthan and around 40 points in Punjab and Uttarakhand (the figures are taken from Table 17 of NFHS-4 state reports for large states; IIPS and ICF, 2017a). The gap is also wide, close to 40 points in Uttar Pradesh and Jharkhand and between 30 and 40 points in Madhya Pradesh, Bihar, Chhattisgarh, Jammu and Kashmir, and Gujarat. At the other end, the gap is narrow, below 20 points in all the southern states and in West Bengal and moderate, 20 to 30 percent, in Assam, Maharashtra, Odisha, and Himachal Pradesh. Thus, son preference seems to be quite strong in the northern and central states and some eastern and western states. Note that desire to stop childbearing after a particular sex composition may lead to stopping strategies, if the desire is translated into practice of contraception, but does not amount to sex selection. But the general pattern of the level of son preference as ascertained from this information is quite similar to that seen in sex selection, though not identical.

Table 14: Women's ownership of house and land, by background characteristics, women ages 15-49, India, NFHS-4, State module

Categories of background characteristics	Owns a house individually or jointly (Percentage distribution)				Owns land individually or jointly (Percentage distribution)				Rural population
	Does not own	Indivi-dually	Jointly	Both indivi-dually and jointly	Does Not own	Indivi-dually only	Jointly only	Both indivi Dually and jointly	Percent of women not Owning any land
Urban	66.1	10.6	13.9	9.4	77.1	5.9	10.2	6.8	-
Rural	61.0	10.6	16.1	12.3	68.6	7.5	13.4	10.4	68.6
No education	55.6	13.1	18.1	13.3	66.3	8.5	14.6	10.6	63.8
Primary	62.1	11.1	15.8	11.0	72.1	7.1	11.8	9.1	69.5
Secondary	65.7	9.5	14.1	10.6	73.6	6.2	11.5	8.7	71.1
Higher	67.4	9.4	13.5	9.7	75.1	6.3	10.9	7.7	72.5
Poorest	56.9	11.2	17.5	14.4	66.0	7.6	14.1	12.2	65.3
Poorer	61.1	10.2	16.5	12.3	68.9	6.7	13.8	10.6	68.1
Middle	63.6	11.2	15.0	10.2	71.7	7.8	12.2	8.4	69.6
Richer	65.3	10.6	14.2	9.8	74.6	6.6	11.3	7.5	71.0
Richest	65.5	10.1	14.0	10.5	75.3	6.2	10.5	8.0	72.0
Did not work	63.3	9.2	15.7	11.8	71.2	6.3	12.7	9.7	67.9
Worked	61.8	13.9	14.2	10.1	72.8	8.4	11.1	7.7	70.1
Hindu	62.2	11.1	15.4	11.3	71.0	7.3	12.5	9.3	68.2
Muslim	65.9	8.1	15.3	10.8	75.1	5.2	11.6	8.1	71.0
Other religions	64.7	10.1	13.7	11.5	73.6	6.8	10.6	9.1	70.6
Non SC/ST/	65.0	9.5	14.4	11.1	73.3	6.3	11.5	8.9	70.5
OBC	63.2	10.8	15.0	11.0	73.2	6.2	11.7	8.8	66.6
SC	59.8	11.8	17.2	11.2	68.0	8.1	14.5	9.4	67.3
ST	62.0	11.0	15.6	11.4	70.8	7.4	12.5	9.4	70.5
OBC									
Central	64.9	5.1	15.4	14.6	73.1	3.3	11.8	11.9	70.5
Southern	60.0	18.0	16.1	5.9	70.7	11.9	12.9	4.5	66.8
Western	69.7	8.8	11.8	9.7	79.1	4.3	9.3	7.3	77.7
Northern	72.2	5.0	11.5	11.4	78.4	3.2	9.1	9.3	60.8
Eastern	54.9	13.1	17.6	14.3	63.4	9.5	14.8	12.3	55.5
Northeastern	48.4	7.6	26.5	17.4	58.0	6.0	21.9	14.1	70.5
Media exposure									
No or low	58.2	10.1	17.1	14.6	66.8	7.0	13.9	12.3	65.6
Moderate	62.0	9.6	16.7	11.7	70.3	6.5	13.6	9.6	67.5
High	64.8	11.0	14.3	9.9	73.8	7.0	11.4	7.8	70.8
All	62.9	10.6	15.3	11.2	71.7	6.9	12.2	9.1	68.6

Source: Computed from NFHS-4 data files.

Overall, sons continue to be more valued than daughters for old age residence and support. Though some changes in preferences and attitudes are seen, these are not large. Perhaps changes in economy and society might bring in a shift towards post-marital neo-local residential arrangements and then parents may have less hesitation in co-residing with married daughters; but such changes are generally slow. The low level of female ownership of land and house shows that in spite of the entitlement under inheritance laws, it is primarily the sons and not daughters who inherit family property. The high level of sex selection in the western and northern regions is consistent with the high reliance on and implicitly high value attached to sons in these regions.

The north-south dichotomy in kinship structure and female autonomy in India has long been recognised and has been linked to regional differences in demographic behaviour (Karve, 1965; Dyson and Moore, 1983). It makes sense to argue that the degree of autonomy women enjoy would correspond to the value of girls to a fairly large extent. We have seen above that the southern region, in which women are known to have greater autonomy than in northern India, has low levels of sex selection. But so do the eastern and northeastern regions. Further, the western region has shown a high level of sex selection. Thus, instead of a north-south dichotomy, we see a pattern with the northern region (as categorized in the NFHS and in this study this is essentially the northwestern part of India) and the western regions showing high degree of sex selection and the southern, eastern, northeastern regions showing low sex selection with the central region falling in the middle.

9 Principal Findings

The sex ratio at birth in India has been more masculine than natural for some time and it is well recognised that this is caused primarily by the practice of gender biased sex selection. Estimates of the SRB are available from a number of sources; civil registration, sample registration, surveys, censuses, and health management information system. The evidence is clear on the point that in the recent decades the SRB has been much more masculine than the natural level. However, the estimates differ and at the national level the SRB varies in a wide range of 860 to 960 excluding some outliers. This study scanned various sources of data to have a clearer idea of the value of SRB and in turn estimate the magnitude of gender biased sex selection. Further, the effect of post-natal discrimination was also assessed in terms of missing girls due to excess female childhood mortality. An analysis of survey data was carried out to see how the SRB varies by the stage of family building; most of the estimates pertain to time periods after 2000. The study also examined socioeconomic and spatial differentials in the sex ratio of birth. Finally, factors associated with son preference and recent changes in the situation were discussed on the basis of evidence from some recent studies. The principal findings are noted below.

1. On the basis of the assessment of various estimates, it can be said that the census based indirect estimate obtained by reverse survival is the most plausible one. At the national level, this was 923 female births per 1000 male births for the period 2004-2011.

2. The SRB in India is clearly more masculine than the natural level but not as high as some of the estimates indicate. The SRS estimate of the SRB (in terms of females per 1000 males) seems to be an underestimate by about 2 percent at the national level and needs to be corrected; the correction factor varies somewhat for states. The SRB has been fluctuating in the range 900 to 930 female births per 1000 male births since 2000 for India with no clear trend.

3. The regional pattern in the SRB is well recognized. States in the northern-western region show much more masculine SRB than in the other regions; some states in the central region also show low ratios but not to the levels of the northern-western regions. The eastern, northeastern, and southern regions generally show ratios near natural. In Punjab, Jammu and Kashmir, and Himachal Pradesh the SRB seems to have risen but is still lower than the natural level.

4. The higher masculinity is on account of the wide-scale prevalence of gender biased sex selection. Close to 400 thousand female births are missed in India annually, amounting to about three percent of female births. The degree (number of missing female births as percent of female births) is high in most states in the northern and western regions, moderate in Uttar Pradesh, Himachal Pradesh and Madhya Pradesh, and low or negligible in most states in the eastern and southern regions.

On the basis of the assessment of various estimates, it can be said that the census based indirect estimate obtained by reverse survival is the most plausible one. At the national level, this was 923 female births per 1000 male births for the period 2004-2011

5. At the 2011 census enumeration, about four million girls of ages 0-6 may be considered to have been missing; 2.5 million on account of sex selection (pre-natal discrimination) and 1.5 million due to excess female mortality (post-natal discrimination). This situation has persisted beyond 2011 as well. Further, while pre-natal discrimination is concentrated in the northern and western regions, post-natal discrimination is common across the country; the southern region and a few other states show relatively low levels but the regional differences in post-natal discrimination are not as wide as seen in the case of pre-natal discrimination.

6. Analysis of SRB by birth order and by sex composition of previous children shows that at higher orders and among those who have no son, the ratios are very highly masculine in the northern, western, and central regions. In the northern region, the SRB at the first order is also more masculine than natural implying that there is some sex selection at the first birth itself indicating that some couples desire to avoid the birth of even one daughter. Moreover, sex selection at the third birth following two daughters seems to be very widely prevalent. This is in line with the findings from John's research (2018), that most families are increasingly averse to the possibility of being a daughter-only family.

Analysis of SRB by birth order and by sex composition of previous children shows that at higher orders and among those who have no son, the ratios are very highly masculine in the northern, western, and central regions

7. Some differences in the SRB by socioeconomic background are seen especially at the second and third births. For the second birth after first daughter, the SRB is generally more masculine than average in the highest education and wealth classes. At the third birth following two daughters, the SRB is highly masculine; this is more so in the most recent period of 2010-14. Further, the SRB is highly masculine at the highest wealth and education levels, in the northern and western regions, and at high media exposure, but not among Muslims.

8. Evidence on perceived values of sons vis-à-vis daughters shows that sons are valued for old age support, financial as well as for residence; such reliance is relatively higher in the northern and western regions compared to other regions. Though some changes in the attitudes are seen in recent investigations, these are not large enough and parents by and large continue to expect such support primarily from sons rather than from daughters. Besides, in spite of the legal entitlements and provisions, it is not common for daughters to inherit parental property. Son preference, clearly, persists.

Before closing, it is necessary to note two major concerns. In order to curb the practice of gender biased sex selection, efforts have been made by enactment of laws and campaigns by the government and civil society organisations. Financial incentives have also been introduced to dissuade couples from resorting to sex selection (for a review, see Sekher, 2012). However, the persistence of highly masculine SRB clearly shows that sex selection has persisted. Some change has been seen in states with very high ratios, Punjab, Haryana, and Himachal Pradesh, but even in these states the SRB is far from the natural level and the SRB in the northern region is highly masculine even at the first birth order. Clearly, the multitude of efforts at preventing sex selection, legal measures, financial incentives, and campaigns has not been successful in eradicating the practice of gender biased sex selection so far. Besides, in recent years, the SRB in some states outside the northern-western region has also become more masculine. Given that son preference is widely prevalent in India, there is the possibility of the practice of sex selection spreading to areas which have hitherto not shown it on a large scale, once the availability of sonographic scan facilities and affordability of the services rise.

Moreover, childhood mortality is higher for females than for males indicating that neglect of the girl child, or post-natal gender discrimination, persists. While the matter of gender biased sex selection has been receiving media and policy attention in India, and rightly so, post-natal discrimination finds little space in the public discourse. It is imperative that civil society and policy makers accord due attention to this concern as well and adopt appropriate measures to address it.

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Appendix

Estimation of the numbers of missing female births, missing girls, and excess female childhood mortality

Estimation of the number of missing female births during 2004-2011

The methodology for the estimation of missing female births is straight forward. First, female and male life tables for the seven-year period 2004-2010 were constructed based on the annual data on age-specific death rates from the SRS (Registrar General, Sample Registration System Statistical Report, various years) and averaging the rates for the seven years. The numbers of female and male births during this period were then computed using the enumerated populations of ages 0-6 in the 2011 census and applying reverse survival. Note that since the census enumeration was on March 1, 2011, ideally the death rates for the period March 2004-February 2011 are needed for the construction of life tables whereas the SRS gives rates for calendar years and thus the life table from the SRS rates for 2004 to 2010 refers to the seven-year period January 2004- December 2010. But the displacement of only two months is not expected to change the life table functions materially since changes in mortality are generally gradual. If the female and male populations in the age group 0-6 in 2011 census enumeration are denoted by FP_{0-6}(2011) and MP_{0-6}(2011) respectively, and ${}_7L_0^{female}$ and ${}_7L_0^{male}$, the standard life table functions for person years for females and males respectively, then the numbers of female and male births during 2004-2011, denoted by FB (2004-2011) and MB (2004-2011) are

$$FB\ (2004\text{-}2011) = FP_{0-6}(2011) / ({}_7L_0^{female}/700000) \text{ and}$$

$$MB\ (2004\text{-}2011) = MP_{0-6}(2011) / ({}_7L_0^{male}/700000) \text{ respectively.} \quad (1)$$

Populations in ages 0-6 by sex are taken from the data set from Registrar General, Census of 2011, Table C-13.

The SRB (expressed as number of female births per 1000 male births) implied by the census via reverse survival is then given as

$$SRB = 1000 \times FB\ (2004\text{-}2011)/MB\ (2004\text{-}2011). \quad (2)$$

Incidentally, this is same method as that employed to estimate SRB by Kumar and Sathyanarayana (2012).

Now, if the SRB had been natural, the number female births during the period, called expected female births and denoted as EFB (2004-2011), is given by

$$EFB\ (2004\text{-}2011) = NSRB^{*}MB\ (2004\text{-}2011)/1000 \quad (3)$$

where NSRB is the natural SRB expressed as female births per 1000 male births. In the calculations in this study, NSRB has been assumed to be 952.

The estimated number of missing female births during the period, denoted by MiFB (2004-2011), is then computed as

$$\text{MiFB (2004-2011)} = \text{EFB (2004-2011)} - \text{FB (2004-2011)}. \quad (4)$$

Estimation of the number of missing girls at the 2011 census enumeration

For the estimation of the effect of excess female mortality in terms of missing girls at a point in time, it is necessary to first estimate 'expected' level of female childhood mortality in the absence of post-natal discrimination. In most populations, female mortality is lower than male mortality and the female mortality level corresponding to a given male mortality level in normal situations (that is, in the absence of post-natal discrimination) is the 'expected' female mortality. In an earlier work (Kulkarni, 2007), the system of Princeton (Coale-Demeny) West Model life tables was invoked, and female mortality at the same level in the model tables as the level of male mortality was accepted as the expected level of female mortality. A recent paper by Guilmoto et al. (2018) has provided a regression relationship between male under-five mortality rate (U5MR) and female U5MR on the basis of data from countries that do not show evidence of post-natal discrimination. The equation is:

$$ {}_5q^f_0 = A \times ({}_5q^m_0)^2 + B \times ({}_5q^m_0) + C. \quad (5)$$

where ${}_5q^f_0$ and ${}_5q^m_0$ are female and male U5MRs (expressed as deaths below age 5 per 1000 births) and A = 0.0006, B = 0.8013 and C = -0.3462.

Using this regression equation, the value of expected U5MR for female was computed from the male U5MR. From this, the expected value of female person years between ages 0 and 7, denoted by ${}_7L^{*\ female}_0$, was obtained. The expected female population of ages 0-6 at the 2011 census, denoted by EFP_{0-6}(2011) was then computed as:

$$EFP_{0-6}(2011) = EFB\ (2004\text{-}2011) \times ({}_7L^{*\ female}_0 / 700000). \quad (6)$$

This is the number of girls of ages 0-6 which would have been present at the 2011 census enumeration in the absence of pre-natal discrimination (gender biased sex selection) and post-natal discrimination (excess female childhood mortality).

The total number of missing girls of ages 0-6 at the 2011 census is simply

$$\text{Missing girls (0-6) in 2011} = EFP_{0-6}(2011) - FP_{0-6}(2011). \quad (7)$$

Further, the number of missing girls due to excess female childhood mortality is

$$FB\ (2004\text{-}2011) \times ({}_7L^{*\ female}_0 - {}_7L^{female}_0)/700000. \quad (8).$$

The number of girls missing due to gender biased sex selection is then given by the difference between these two terms. This can also be obtained directly as

$$MiFB\ (2004\text{-}10) \times ({}_7L^{*\ female}_0 / 700000). \quad (9)$$

Estimation of the number of missing female births during 2011-2016

For estimation of the numbers of missing female births during a specified period, information on the numbers of births by sex is essential. For the period before the census, the reverse survival method was employed for this purpose but this approach cannot obviously be used for period after the census. Since the civil registration system does not provide a complete coverage, one must resort to the estimates of the crude birth rate from the SRS and in combination with the SRB from the SRS and projected population size, estimate the numbers of births by sex. Normally, the Office of Registrar General of India prepares and publishes population projections some time after every census but so far no such projections have been released after the 2011 census. Hence, projections made by the author independently have been used. Of course, making population projections involve assumptions on future (that is, for periods after 2011) levels of fertility, mortality, and migration with 2011 census as the baseline and these would vary in different projections but for a short period, such variations do not influence the projected total size of population substantially. Therefore, the population size in the projections by the author combined with crude birth rates from the SRS are used here to estimate the numbers of births over 2011-2016 and then, by applying the SRB, the number of male and female births computed. For this purpose, populations at mid-years were interpolated from the 2011 and 2016 projected populations and the SRS crude birth rates applied to these to compute the numbers of births in each year. The SRS estimates of the SRB, which are available as three-year averages were used for the middle year and further adjusted by the factor shown in Table 3 (this is the ratio shown in the column SRS Est./Census based estimate of the Table for India and for individual states; since such ratio was not available for Uttarakhand, the adjustment factor for India was applied). For both the crude births rates and the SRB, the estimates are for calendar years but were used for the periods March 2011-February 2012 and so on ignoring the displacement of two months. Applying the adjusted SRB to the number of births, the numbers of female and male births were computed. The steps are:

Let P_i = Projected population at mid-year for year i,

where i = 1 for 2011-2012, 2 for 2012-2013, 3 for 2013-2014, 4 for 2014-2015, 5 for 2015-2016.

CBR_i = crude birth rate for year i (per 1000 population), and

SRB_i = SRB for year i, taken from the three-year average SRB for the years, i-1, i, i+2.

Then, the number of births in year i, the number of female births in year i, and the number of male births in year i, denoted by B_i, FB_i, and MB_i respectively, are given by

$$B_i = P_i \times CBR_i / 1000,$$

$$FB_i = B_i \times (SRBi/A)/((SRB_i/A) + 1000), \text{ and}$$

$$MB_i = B_i - FB_i, \qquad (10)$$

where A is the adjustment factor for SRB (this is the ratio shown in the column SRS Est/Census based estimate of Table 3).

Now,

FB(2011-16) = Number of female births during 2011-16 $= \Sigma FB_i$, and

MB(2011-16) = Number of male births during 2011-16 $= \Sigma MB_i$,

the sum being over i = 1, 5. (11)

Then, Expected number of female births during 2011-16, denoted by EFB (2011-16), is given by

EFB (2011-16) = NSRB* MB (2011-16)/1000. (12)

The number of missing female births during 2011-2016, MiFB (2011-16), is then given by

MiFB (2011-16) = EFB (2011-16) – FB (2011-16). (13)

Estimation of the number of excess female under-five deaths out of births during 2011-16

In order to estimate the impact of excess under-five female mortality, it is necessary to first compute female and male under-five mortality rates. Averages of age-specific deaths rates from the SRS for the years 2011-2015 were obtained by sex and life tables constructed for the period and from these the values of U5MR for males and females were taken. The expected U5MR for females corresponding to male U5MR was computed using the regression equation given by Guilmoto et al (2018), reproduced as eq(5) above, and the estimated number of excess female deaths under age 5 obtained as

FB(2011-16) x [Female U5MR – Expected Female U5MR]/1000. (14)

Ideally, U5MR from cohort life tables should be used for this purpose. However, changes in mortality over time are very slow when the life expectancy is close to 70 years or higher and hence period life tables serve the purpose quite well.

Appendix Tables

Appendix Table 1: Sex Ratio at Birth from the Civil Registration System, India, States, and Union Territories, 2000-2016
(female births per 1000 male births based on registered births)

State/ Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
INDIA	886	875	872	868	872	876	891	903	904	898	857	909	908	898	887	881	877
Andhra Pradesh	936	934	936	973	972	987	973	974	986	985	983	983	985	954	955	971	806
Arunachal Pradesh	728	887	806	812	864	799	792	854	875	806	792	897	819	978	993	895	964
Assam	na	na	na	750	na	732	876	834	853	931	1244	920	872	909	902	885	888
Bihar	na	984	779	826	801	793	na	na	na	715	@	na	Na	924	868	870	837
Chhattisgarh	933	925	920	926	919	939	919	919	886	924	906	915	895	925	934	938	980
Delhi	820	809	831	823	823	822	831	848	1004	915	901	893	886	895	896	898	902
Goa	918	919	929	931	931	931	963	947	931	921	908	934	929	946	947	928	900
Gujarat	816	802	826	835	824	846	972	879	883	905	902	901	902	901	886	na	na
Haryana	792	789	829	814	796	827	857	860	854	853	838	833	832	840	843	851	865
Himachal Pradesh	857	856	866	877	872	866	885	903	904	922	911	918	916	906	896	903	910
Jammu & Kashmir α	879	916	923	925	934	923	906	922	906	918	917	913	Na	923	914	912	914
Jharkhand	na	na	na	na	840	830	835	865	878	864	865	na	847	885	886	879	863
Karnataka	955	971	956	924	858	943	952	1004	1047	1011	1025	983	971	943	926	893	896
Kerala	998	968	944	951	946	949	955	944	952	942	939	939	955	942	948	948	954
Madhya Pradesh	869	841	823	841	864	855	855	905	913	938	922	897	912	904	908	904	909
Maharashtra	847	819	826	808	811	na	na	na	870	868	854	861	894	901	911	883	904
Manipur	914	753	949	923	1004	1011	963	913	950	934	770	816	797	700	684	686	na
Meghalaya	934	942	976	875	1011	918	965	864	959	948	912	942	947	978	968	975	na
Mizoram	911	927	913	926	945	940	952	938	942	949	948	972	968	954	963	973	964
Nagaland	820	894	980	971	977	980	804	823	802	883	871	873	873	873	860	897	967
Odisha	947	939	988	950	927	934	927	919	935	925	911	902	896	886	880	866	858
Punjab	747	754	777	789	794	790	813	820	820	822	824	852	844	876	880	891	857
Rajasthan	821	825	806	833	820	805	828	832	785	861	839	911	861	859	799	794	806
Sikkim	973	936	1252	935	956	954	941	981	951	955	961	947	974	956	968	973	999
Tamil Nadu	922	929	926	920	936	935	939	935	928	933	935	905	904	853	834	818	840

Appendix Table 1: Sex Ratio at Birth from the Civil Registration System, India, States, and Union Territories, 2000-2016
(female births per 1000 male births based on registered births)

State/ Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Telangana					(included in Andhra Pradesh)									954	961	834	881
Tripura	931	914	1121	1202	na	na	na	na	na	na	996	982	980	1055	882	1000	917
Uttar Pradesh	na	na	na	na	na	na	na	na	na	na	na	na	930	883	881	877	885
Uttarakhand	na	na	na	na	845	864	873	869	860	855	858	869	847	843	865	862	825
West Bengal	932	904	882	889	903	906	890	918	914	929	931	924	926	913	897	919	911
Union Territories																	
A & Nicobar	946	968	927	1003	935	967	933	949	961	973	934	954	934	947	1031	925	987
Chandigarh	751	771	827	807	786	826	860	860	872	867	878	835	887	904	870	898	901
Dadra & N Haveli	903	865	833	932	879	918	895	917	946	928	905	960	954	876	890	1001	945
Daman & Diu	897	860	876	915	906	869	847	908	916	934	912	857	886	961	916	924	974
Lakshadweep	907	908	968	991	843	869	899	911	934	866	1015	897	Na	969	1043	891	945
Puducherry	942	946	937	942	936	950	955	950	923	927	917	912	909	910	911	939	931
Level of coverage of births under registration (percent)																	
India	56.2	58.0	59.5	57.7	60.4	62.5	69.0	74.5	76.4	81.3	82.0	83.6	84.4	85.6	88.8	88.3	86.0

@ The value of SRB for Bihar in 2010 as given in the report does is 323 and is prima facie incorrect.

α : Including Ladakh

Source: Registrar General (2013a, 2018a)

Appendix Table 2: Estimates of Sex Ratio at Birth for India and Large States From SRS, 1998 onwards
(female births per 1000 male births)

Period	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016
Mid-year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
INDIA	898	894	892	883	882	880	892	901	904	906	905	906	908	909	906	900	898
Andhra Pradesh β	960	934	945	932	916	917	917	915	917	919	920	915	914	916	919	918	913
Assam	984	962	945	904	915	907	920	939	933	937	928	926	922	920	918	900	896
Bihar	896	873	870	861	863	865	881	909	914	917	912	910	909	911	907	916	908
Chhattisgarh					964	947	961	969	975	980	985	991	979	970	973	961	963
Delhi					835	831	847	871	877	882	884	880	884	887	876	869	857
Gujarat	851	837	844	862	855	844	865	891	898	904	903	909	909	911	907	854	848
Haryana	797	803	804	807	821	829	837	843	847	849	848	854	857	864	866	831	832
Himachal Pr.	902	858	826	803	851	858	872	931	938	944	942	938	939	943	938	924	917
Jammu. & Kashmir α					816	824	838	854	862	870	873	880	895	902	899	899	906
Jharkhand					865	872	888	927	922	921	919	915	918	913	910	902	918
Karnataka	942	935	952	943	923	915	917	926	935	944	943	945	950	958	950	939	935
Kerala	930	927	911	892	889	912	922	958	964	968	966	965	966	966	974	967	959
Madhya Pr.	907	915	920	922	916	911	913	913	919	926	921	920	921	920	927	919	922
Maharashtra	913	915	899	887	878	872	879	871	884	896	895	893	896	902	896	878	876
Orissa	928	920	944	934	944	932	934	933	937	941	938	946	948	956	953	950	948
Punjab	792	775	775	776	797	801	808	837	836	836	832	841	863	867	870	889	893
Rajasthan	877	885	890	855	838	839	855	865	870	875	877	878	893	893	893	861	857
Tamil Nadu	931	926	926	953	946	943	955	944	936	929	927	926	928	927	921	911	915
Uttar Pradesh	868	870	864	853	859	862	874	881	877	874	870	875	874	878	869	879	882
West Bengal	952	956	949	937	931	926	931	936	941	944	938	941	944	943	952	951	937

Source: Registrar General (various years, 2001-2018).

β: *Including Telangana;* α: *Including Ladakh*

Appendix Table 3: Estimates of Sex Ratio at Birth for India and States, 2001 and 2011 Census Data
(female births per 1000 male births)

	2001 Census		2011 Census		Indirect estimate from	
	Based on		Based on		Child sex ratio (0-6 years) #	
	CEB $	BLY @	CEB $	BLY @	2001 census	2011 Census
Reference period		2000-01		2010-11	1994-2000	2004-10
INDIA	939	906	928	899	935	923
Andhra Pradesh β	961	951	929	924	959	938
Assam	964	948	963	930	968	961
Bihar	935	917	929	892	954	943
Chhattisgarh	975	928	965	948	983	971
Delhi	903	852	1001	869	865	873
Gujarat	896	834	904	868	890	895
Haryana	864	786	878	824	838	845
Himachal Pradesh	919	845	969	948	898	916
Jammu & Kashmir α	915	951	888	774	na	866
Jharkhand	962	907	941	903	977	958
Karnataka	953	936	951	922	944	949
Kerala	964	969	966	977	959	965
Madhya Pradesh	942	903	944	908	941	923
Maharashtra	927	877	905	862	915	896
Orissa	966	928	941	910	951	942
Punjab	851	787	882	843	809	854
Rajasthan	918	864	903	899	924	897
Tamil Nadu	954	935	927	934	945	942
Uttar Pradesh	937	901	919	890	936	914
West Bengal	962	976	947	937	953	954
Arunachal Pradesh	978	997	954	935	965	972
Goa	943	921	903	908	931	943
Manipur	969	976	929	905	957	937
Meghalaya	990	958	982	978	960	967
Mizoram	997	994	977	966	949	970
Nagaland	954	984	956	965	na	944
Sikkim	994	937	956	965	948	960
Tripura	974	973	963	956	964	958
Utttarakhand	938	853	931	869	928	895

$: CEB: Children ever born to women of ages 20-29 at census; @: BLY: Births last year

#: Estimated from child sex ratio ages 0-6 by Kumar and Sathyanarayana (2012)

β : including Telangana; α : Including Ladakh. na: Not available.

Source: CEB and BLY estimates computed from 2001 and 2011 Census fertility tables.

Appendix Table 4: Trends in Sex Ratio at Births based on NFHS-3 and NFHS-4
(female births per 1000 male births)

Survey	NFHS-3		NFHS-4		
Period	1995-1999	2000-2004	2000-2004	2005-2009	2010-2014
Mid-year	1997	2002	2002	2007	2012
India	930	919	917	919	911
Jammu & Kashmir α	900	913	887	928	909
Himachal Pradesh	938	898	923	943	928
Punjab	751	742	816	853	845
Uttarakhand	912	878	913	908	878
Haryana	910	723	777	810	846
Delhi	874	857	921	759	821
Rajasthan	931	897	886	881	869
Uttar Pradesh	931	915	893	917	896
Bihar	927	921	944	939	931
Sikkim	1000	929	904	955	800
Arunachal	974	1000	1008	915	911
Nagaland	896	922	924	957	953
Manipur	921	1017	931	959	964
Mizoram	962	1083	981	956	982
Tripura	966	976	973	952	941
Meghalaya	945	935	976	929	990
Assam	952	980	945	975	901
West Bengal	953	947	931	927	947
Jharkhand	1027	1063	949	942	930
Odisha	862	887	957	948	941
Chhattisgarh	969	890	922	923	913
Madhya Pradesh	993	1014	922	923	913
Gujarat	895	898	864	946	873
Maharashtra	944	865	935	869	911
Andhra Pradesh including Telangana	909	872	946	951	888
Andhra Pradesh	na	na	943	948	899
Telangana	na	na	951	954	874
Karnataka	878	971	970	918	909
Goa	893	929	977	867	945
Kerala	1005	934	972	941	1027
Tamil Nadu	933	992	909	955	950

Source: Computed from NFHS-3 and NFHS-4 data files.

na: Not available.

α: Including Ladakh

Appendix Table 5: Sex Ratio at Birth from HMIS reports, India, States and Union Territories, 2008/09 to 2017/18
(female births per 1000 male births)

State/ Year	Year									
	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
India	900	927	913	917	915	918	918	923	926	929
A & N Islands	na	956	923	971	954	959	967	890	1003	897
Andhra Pradesh	915	946	938	943	931	926	921	951	946	958
Arunachal Pradesh	995	911	942	918	931	921	916	951	936	956
Assam	927	885	903	924	917	928	920	922	936	938
Bihar	797	1129	935	946	932	941	936	928	918	910
Chandigarh	806	898	881	867	889	899	874	906	921	897
Chhattisgarh	969	968	964	930	920	923	930	931	946	961
Dadra & Nagar Haveli	945	919	901	928	947	936	939	951	934	919
Daman & Diu	na	Na	1062	936	915	960	894	906	972	894
Delhi	900	871	882	891	888	893	901	904	908	917
Goa	865	919	923	963	934	905	939	918	937	942
Gujarat	904	904	894	890	891	900	901	907	910	910
Haryana	874	854	853	865	865	883	876	887	902	914
Himachal Pradesh	886	898	880	896	894	894	897	908	916	931
Jammu & Kashmir α	924	891	909	921	913	937	936	942	947	958
Jharkhand	896	914	908	912	921	918	920	924	918	921
Karnataka	937	948	923	935	942	941	945	943	948	940
Kerala	914	957	960	950	955	952	959	953	958	964
Lakshadweep	Na	1054	951	891	866	1021	1000	832	955	885
Madhya Pradesh	928	929	936	936	932	924	926	929	937	929
Maharashtra	886	881	870	889	910	921	920	924	922	940
Manipur	978	957	978	932	941	918	933	936	952	914
Meghalaya	1012	959	940	953	960	953	938	952	949	936
Mizoram	904	922	962	936	953	948	971	955	980	958
Nagaland	994	928	955	900	925	912	948	904	923	921
Odisha	992	936	927	924	932	940	948	943	940	936
Puducherry	912	914	924	903	927	898	916	948	931	939
Punjab	902	878	884	885	884	890	892	891	902	907
Rajasthan	905	901	893	900	906	924	929	929	938	945
Sikkim	1014	942	946	920	985	959	957	998	954	928
Tamil Nadu	950	947	943	933	924	923	917	935	938	947
Telangana	Included in Andhra Pradesh						925	947	941	925
Tripura	899	935	922	924	936	940	958	930	954	946
Uttar Pradesh	870	909	907	909	891	888	885	902	906	911
Uttarakhand	947	901	910	894	911	907	903	906	914	922
West Bengal	846	922	928	927	935	931	942	937	936	942

Source: HMIS (2018).

na: Not available.

α: Including Ladakh

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