Missing female births in India

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Prenatal sex selection for non-medical reasons is a heated issue. Prenatal diagnosis involves an early invasive procedure, such as chorionic villus sampling, between 10 and 12 weeks of gestation[1] or, in the later stages, ultrasonography or amniocentesis. In today's *Lancet*, Prabhat Jha and colleagues[2] present a large study of 1·1 million Indian households to examine the causes of missing girls at birth.

In the UK after a second public consultation, the Human Fertilisation and Embryology Authority reaffirmed its position opposing sex selection for non-medical reasons.[3] In India, fetal sex determination and medical termination of pregnancy on the basis of fetal sex have been illegal since 1994. Under the law, prenatal diagnostic scans are allowed for the detection of genetic abnormalities, but sex determination tests are forbidden. Those caught are subject to a fine, imprisonment, and suspension of the medical practitioner's licence.[4]

However, there is ample published evidence of rampant sex determination and female feticide.[5] Events in India[6,7] and China[8,9] show that some couples prefer to have a boy and believe that their family is unbalanced without a son. In a country bedevilled in many parts by cultural taboos, a boy is preferred because he will continue the family name and bloodline, earn money, look after the family, and take care of parents in their old age. There is no social security scheme in India.

To have a daughter is socially and emotionally accepted if there is a son, but a daughter's arrival is often unwelcome if the couple already have a daughter. Daughters are regarded as a liability. Because she will eventually belong to the family of her future husband, expenditure on a daughter will benefit others. In some communities where the custom of dowry prevails, the cost of her dowry could be phenomenal and many families are forced to borrow money to fund them. If a daughter remains unmarried, she is a burden to her parents. She is unable to work to support her parents because of lack of education, and because her parents may want to protect her from influences outside the family home.

In many developing countries, the life of a woman revolves around a joint family consisting of in-laws, and homebound duties are an inevitable part of her daily life. Jha and colleagues mention "ever-married" women. This description is apt for most Indian women who spend their lives in the service of their families, except in cases where influences from developed countries have crept in during the past few decades. In this society, women are dependent on their husbands and in turn, both are dependent on his parents. A woman might be deemed a culprit if she does not give birth to a boy, although scientifically it is the husband who is responsible for the sex of the child. The prejudice and dislike for the woman by a demanding mother-in-law and/or bossy father-in-law make the couple's life miserable and they often succumb to pressure to have prenatal sex determination.

Female infanticide[10] of the past is refined and honed to a fine skill in this modern guise. It is ushered in earlier, more in urban areas and by the more educated, with the help of advanced technologies in the form of selective abortion of the female fetus whether in single or multiple pregnancies. A careful demographic analysis of actual and expected sex ratios shows that about 100 million girls are missing from the world—they are dead.[11]

AP

The low sex ratio in India[6,12] and China[8,9] (around 700–900 females to every 1000 males) has invited profound thinking. There are several hypotheses for non-equality in the sex ratio. Studies from France[13,14] and Norway[15] suggest greater susceptibility to preterm labour and stronger intrauterine selection forces for the male fetus. Are there unearthed scientific factors, particularly in the developing world, responsible for the lower number of girls, or should we continue to concentrate on prenatal sex determination?

Concentration on respecting women's sexual and reproductive rights as well as their human rights can be the only answer to this problem. In 1986, the Federation of Obstetric and Gynaecological Societies of India passed a resolution against prenatal sex determination and medical termination of pregnancy because of the sex of the fetus. All members of the federation are asked to desist, dissociate, and discourage female feticide as it is a "crime against humanity".[16]

To eliminate prenatal sex selection and consequent termination of human life is a Herculean task. We can draw inspiration from Dr A P J Abdul Kalam, the President of India, who has said: "We have to demand from our institutions the impossible and the possible will emerge."[17]

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Low male-to-female sex ratio of children born in India: national survey of 1·1 million households

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Summary

Background **Fewer girls than boys are born in India. Various hypotheses have been proposed to explain this low sex ratio. Our aim was to ascertain the contribution of prenatal sex determination and selective abortion as measured by previous birth sex.**

Methods **We analysed data obtained for the Special Fertility and Mortality Survey undertaken in 1998. Ever-married women living in 1·1 million households in 6671 nationally-representative units were asked questions about their fertility history and children born in 1997.**

Findings **For the 133 738 births studied for 1997, the adjusted sex ratio for the second birth when the preceding child was a girl was 759 per 1000 males (99% CI 731–787). The adjusted sex ratio for the third child was 719 (675–762) if the previous two children were girls. By contrast, adjusted sex ratios for second or third births if the previous children were boys were about equal (1102 and 1176, respectively). Mothers with grade 10 or higher education had a significantly lower adjusted sex ratio (683, 610–756) than did illiterate mothers (869, 820–917). Stillbirths and neonatal deaths were more commonly male, and the numbers of stillbirths were fewer than the numbers of missing births, suggesting that female infanticide does not account for the difference.**

Interpretation **Prenatal sex determination followed by selective abortion of female fetuses is the most plausible explanation for the low sex ratio at birth in India. Women most clearly at risk are those who already have one or two female children. Based on conservative assumptions, the practice accounts for about 0·5 million missing female births yearly, translating over the past 2 decades into the abortion of some 10 million female fetuses.**

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Introduction

There are fewer girls than boys in India, and this sex ratio has become more skewed towards boys in recent decades; in the decennial census,[1] the number of girls per 1000 boys aged 0–6 years was 962 in 1981, 945 in 1991, and 927 in 2001, and the discrepancy was more acute in urban areas (from 959 to 906 between 1981 and 2001) than in rural ones (963 to 934). The difference in sex ratio is evident by age 1 year, suggesting that fewer girls than boys are born, and widens thereafter because of the higher mortality rates in female children than in male children.[2] Low sex ratios have also been recorded in other Asian countries,[3] most notably China, where 847–877 girls were born for every 1000 boys in 2002.[4] India has higher fertility rates than China.[3] Thus, factors that lead to fewer female than male births might result in greater absolute differences in the age-specific female and male populations, especially if these factors are maintained for several decades.

There are various possible explanations for unequal sex ratios at birth, including lower caloric intake by mothers,[5] Hepatitis B virus infection,[6] father's occupation[7] or his absence from the home,[8] maternal dominance,[9] smoking,[10] and hormonal factors,[11] time taken to conceive,[12] female infanticide,[13] and under-reporting of female births.[14,15] In India, there is a cultural preference for boys,[2] however, and the most plausible explanation for fewer female than male births seems to be prenatal sex determination, followed by induced abortion of female fetuses.[14,16–20] Anecdotal evidence suggests that access to ultrasound is fairly widespread, even in rural areas,[15,21,22] and although prenatal sex determination has been illegal since 1994 the law is often ignored.[23] Self-reporting of prenatal sex determination probably results in underestimation of the problem and makes defining its role in the low sex ratio at birth of girls to boys difficult.

Our aim was to ascertain whether prenatal sex determination affects sex ratios at birth as measured by previous birth sex and to estimate the contribution of fewer female than male births to the estimated totals of so-called missing women in India.[24,25]

Methods

Survey population

In February, 1998, a survey of households in India was done to obtain a detailed fertility history of ever-married women.[26] The Special Fertility and Mortality Survey (SFMS)[26] was undertaken by the Office of the Registrar General of India in the sample units (or small areas) of the Sample Registration System (SRS), which is an ongoing large-scale demographic survey that provides reliable yearly estimates of fertility and mortality indicators at the national level and for major states.[27] The SRS sample frame covers 6 million people, living in about 1·1 million households in 35 states or union territories of India. The states of Jammu and Kashmir, and the rural units of Nagaland were not included in the SFMS. The 6671 (4436 rural and 2235 urban) SRS units

	Sex of previous children	Number of births			Adjusted sex ratio (99% CI)
		Female	Male	Total	
Overall					
1	..	17 417	20 760	38 177	871 (849–893)
2	Male	9289	8749	18 038	1102 (1062–1143)
	Female	7686	10 517	18 203	759 (731–787)
3	Both male	2954	2608	5562	1176 (1098–1254)
	Both female	2774	4008	6782	719 (675–762)
	One male, one female	5323	6089	11 412	908 (866–950)
>4	..	16 629	18 935	35 564	912 (888–936)
All	..	62 072	71 666	133 738	899 (887–911)
Rural residence					
1	..	13 858	16 506	30 364	873 (848–898)
2	Male	7491	7071	14 562	1101 (1057–1146)
	Female	6228	8500	14 728	762 (731–793)
3	Both male	2528	2189	4717	1201 (1114–1287)
	Both female	2351	3297	5648	741 (692–791)
	One male, one female	4556	5153	9709	919 (873–965)
>4	..	14 506	16 602	31 108	908 (883–934)
All	..	51 518	59 318	110 836	903 (890–916)
Urban residence					
1	..	3559	4254	7813	859 (811–908)
2	Male	1798	1678	3476	1101 (1008–1194)
	Female	1458	2017	3475	743 (679–806)
3	Both male	426	419	845	1044 (865–1223)
	Both female	423	711	1134	611 (518–705)
	One male, one female	767	936	1703	842 (740–944)
>4	..	2123	2333	4456	935 (865–1005)
All	**..**	**10 554**	**12 348**	**22 902**	**878 (849–907)**

Table 1: **Sex ratio (females per 1000 males) for births in 1997 to married women by birth order and sex of previous child(ren)**

(each comprising about 150 households and 900 people) were randomly selected based on the 1991 census to be representative of the population at the state level. About 20–25 births and nine deaths arise yearly per unit. Vital events are surveyed monthly by locally resident part-time enumerators, and an independent survey is done every 6 months by full-time supervisors. Details of the SRS and SFMS sample design and field methods are published elsewhere.[26,27] The SRS obtains oral consent of households and follows confidentiality and ethical guidelines under the Registration of Births and Deaths Act and as per ongoing census activities.

Procedures

The SFMS included a detailed fertility history of all ever-married women as of Jan 1, 1998. Questions asked that were pertinent to fertility and, therefore, this study included current age, age at marriage, husband's age at marriage, educational level of the woman and her husband, and number of stillbirths, livebirths, and children ever born. Relevant questions about all children born in 1997 included date of birth, birth order, sex, age of the mother, interval between most recent and previous birth, and type of medical attention received at birth. To avoid reporting bias, no direct questions were asked about whether parents had a preference for boys or girls, or about use of prenatal sex determination or abortion. The fieldwork was done by about 700 trained supervisors of the SRS state implementing agencies who undertake the SRS half-yearly surveys. Missing or incomplete data are excluded from this report.

Statistical analysis

The basic ratio presented here is the adjusted sex ratio at birth, defined as the number of female births per 1000 male births ($Pf/(1-Pf)*1000$; where Pf is the proportion of female to total births [N]). The number of births detected in the SRS is higher than that noted in the SFMS because of dual (monthly and 6-monthly) recording, shorter recall period, and prospective follow up. To allow comparison of the two datasets,[26,27] we have adjusted upwards the deficit in numbers by 3·9% (with

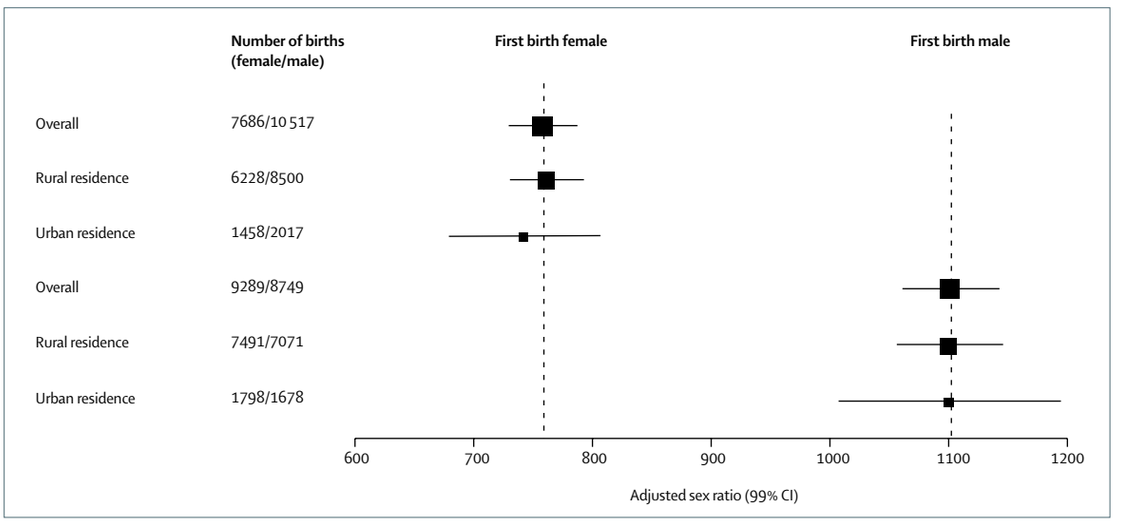

Figure 1: **Conditional sex ratio for second births by sex of previous birth and residence, 1997**
Sex ratios adjusted to SRS (1997) overall sex ratio at birth for India, stratified by rural and urban status. Size of squares is proportional to square root of total births in that category and is normalised to total births for India.

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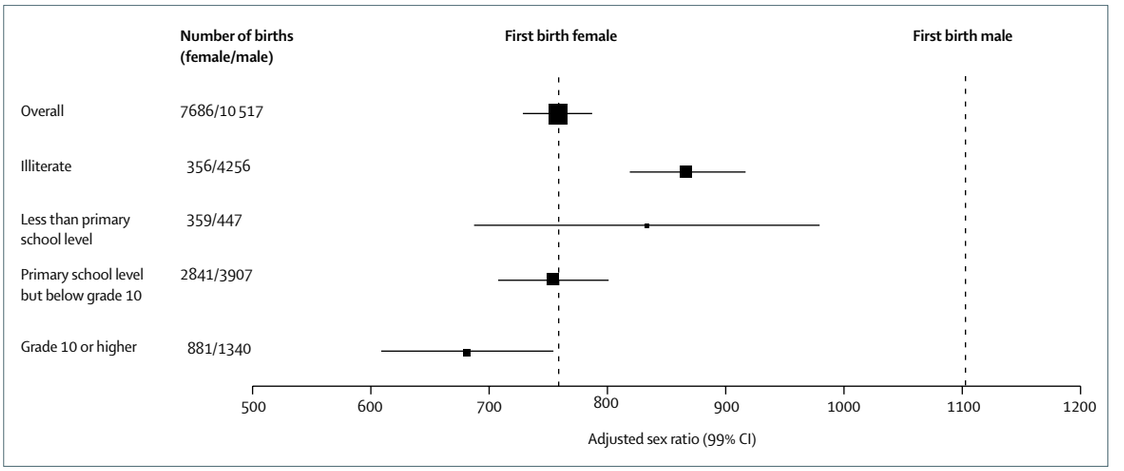

Figure 2: **Conditional sex ratio for second female births by education level of mother, 1997**
Sex ratios adjusted to SRS (1997) overall sex ratio at birth for India. Size of the squares is proportional to square root of total births in that category and is normalised to total births for India.

the exact upward correction depending on rural or urban status and state). However, the differences in unadjusted and adjusted sex ratios were not significant and the raw numbers from the SFMS are provided in the tables and figures. We derived 99% CI based on the Delta method,[28] with a variance of $Pf/[N^*(1-Pf)^3$. We used multivariate logistic regression analyses with maximum likelihood estimates to compare the log odds of a second female child by comparison with the sex of the first child, with adjustment for religion, rural or urban place of residence, education (illiterate, literate but less than primary school level, primary school level but below grade 10 [about age 15 years], or grade 10 or beyond) of mother and her husband, age of mother and her husband, age at marriage, and state. We mainly present analyses for second-order births rather than third-order or higher-order births because more families had two children than more than two children. We used SAS (version 8.2) for all statistical analyses.

Role of the funding source
The sponsors of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all relevant data in the study and had final responsibility for the decision to submit for publication.

Results
136 457 births were recorded in the SFMS, of which 133 738 are analysed here. Of these, 95 561 were second-order or higher-order births. Operational problems meant 237 units (about 3% of the population) did not complete fieldwork or data entry. The missing SRS units differed little from units included in the SFMS in sex ratios and other demographic variables. Fewer births were reported in the SFMS than in the SRS, the shortfall being higher for girls (14%, n=9950) than for boys (10%, n=7732). Under-reporting of births varied by state, but did not vary greatly by rural or urban residence within

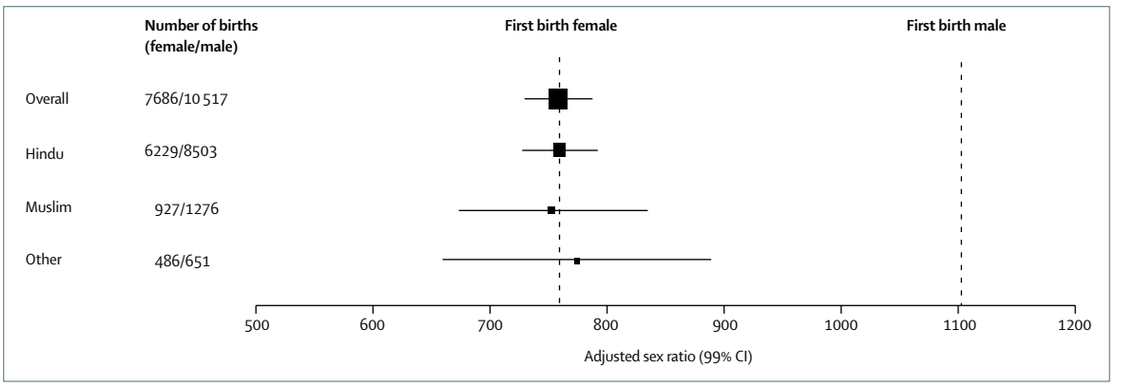

Figure 3: **Conditional sex ratio for second female births by religion of mother, 1997**
Sex ratios adjusted to SRS (1997) overall sex ratio at birth for India. Size of squares is proportional to square root of total births in that category and is normalised to total births for India.

	Overall				Rural residence				Urban residence			
	Female	Male	Number of Births	Adjusted sex ratio (99% CI)	Female	Male	Number of Births	Adjusted sex ratio (99% CI)	Female	Male	Number of livebirths	Adjusted sex ratio (99% CI)
If first birth was female												
Total	7686	10 517	18 203	759 (731–787)	6228	8500	14 728	761 (730–792)	1458	2017	3475	751 (687–814)
Andhra Pradesh	415	486	901	899 (753–1045)	327	386	713	892 (729–1055)	88	100	188	927 (597–1256)
Assam	337	349	686	993 (805–1182)	290	298	588	1001 (796–1207)	47	51	98	948 (471–1425)
Bihar	645	1074	1719	638 (561–714)	590	972	1562	644 (563–726)	55	102	157	572 (342–803)
Delhi	104	171	275	631 (437–824)	17	27	44	653 (154–1152)	87	144	231	627 (417–837)
Gujarat	366	549	915	670 (555–785)	307	459	766	672 (546–798)	59	90	149	659 (378–940)
Haryana	268	433	701	667 (544–790)	211	333	544	683 (540–825)	57	100	157	614 (372–856)
Himachal Pradesh	132	201	333	710 (522–898)	104	157	261	716 (502–930)	28	44	72	688 (294–1082)
Karnataka	500	550	1050	955 (811–1099)	408	449	857	955 (796–1114)	92	101	193	957 (621–1293)
Kerala	392	537	929	765 (641–889)	306	422	728	760 (621–899)	86	115	201	784 (511–1057)
Madhya Pradesh	614	679	1293	927 (798–1056)	516	597	1113	886 (753–1019)	98	82	180	1225 (767–1683)
Maharashtra	398	581	979	749 (635–864)	275	409	684	736 (601–870)	123	172	295	782 (566–999)
Orissa	386	543	929	719 (598–840)	325	456	781	721 (589–854)	61	87	148	709 (410–1009)
Punjab	189	328	517	614 (479–749)	148	250	398	631 (473–788)	41	78	119	560 (300–820)
Rajasthan	452	692	1144	674 (573–775)	407	604	1011	695 (584–806)	45	88	133	527 (288–767)
Tamil Nadu	437	547	984	860 (729–991)	298	372	670	863 (703–1022)	139	175	314	855 (624–1086)
Uttar Pradesh	799	1202	2001	677 (599–755)	684	1024	1708	680 (596–765)	115	178	293	658 (460–856)
West Bengal	607	757	1364	822 (710–934)	512	624	1136	841 (716–966)	95	133	228	732 (487–978)
If first birth was male												
Total	9289	8749	18 038	1103 (1062–1143)	7491	7071	14 562	1100 (1055–1145)	1798	1678	3476	1113 (1020–1206)
Andhra Pradesh	466	436	902	1125 (943–1308)	364	353	717	1086 (889–1283)	102	83	185	1294 (829–1759)
Assam	339	388	727	899 (733–1065)	282	330	612	879 (702–1057)	57	58	115	1011 (542–1480)
Bihar	888	838	1726	1125 (994–1256)	798	761	1559	1113 (977–1249)	90	77	167	1241 (776–1705)
Delhi	160	157	317	1057 (764–1350)	39	28	67	1445 (562–2328)	121	129	250	973 (669–1277)
Gujarat	492	409	901	1209 (1003–1415)	403	335	738	1209 (981–1436)	89	74	163	1208 (724–1693)
Haryana	354	394	748	968 (799–1136)	278	316	594	948 (763–1133)	76	78	154	1050 (648–1452)
Himachal Pradesh	156	173	329	975 (720–1230)	123	133	256	1000 (704–1296)	33	40	73	892 (395–1388)
Karnataka	524	568	1092	969 (826–1112)	433	459	892	991 (829–1153)	91	109	200	877 (574–1181)
Kerala	458	420	878	1143 (954–1332)	354	320	674	1159 (941–1378)	104	100	204	1090 (717–1463)
Madhya Pradesh	683	641	1324	1092 (942–1242)	608	545	1153	1143 (975–1312)	75	96	171	801 (493–1109)
Maharashtra	506	474	980	1168 (993–1343)	353	322	675	1199 (983–1416)	153	152	305	1101 (806–1396)
Orissa	481	388	869	1254 (1038–1471)	407	325	732	1267 (1029–1506)	74	63	137	1189 (673–1704)
Punjab	225	239	464	1003 (779–1227)	165	181	346	971 (720–1222)	60	58	118	1102 (614–1590)
Rajasthan	595	515	1110	1192 (1014–1370)	518	455	973	1174 (987–1362)	77	60	137	1324 (758–1889)
Tamil Nadu	525	462	987	1224 (1038–1409)	349	333	682	1128 (923–1334)	176	129	305	1469 (1064–1874)
Uttar Pradesh	1025	929	1954	1124 (996–1252)	880	810	1690	1107 (971–1242)	145	119	264	1241 (855–1627)
West Bengal	660	619	1279	1093 (940–1246)	557	517	1074	1104 (936–1273)	103	102	205	1035 (674–1396)

Table 2: **Sex ratio (females per 1000 males) for second-order births by state**

states. There was no correlation between the shortfall of female births and the overall sex ratios in the SFMS (Pearson correlation R^2=0·07). The crude sex ratio for all births in the SRS was higher than in the SFMS (899 females per 1000 males *vs* 866). The proportion of births by birth order was comparable in the two survey populations (data not shown). Rates of stillbirths and neonatal deaths per 1000 births were slightly higher in the SRS (data not shown).

Table 1 shows the number of girls and boys born stratified by residence. Overall, there were 9594 fewer female than male births. For first-order births, which represented 29% of all births in 1997, the adjusted sex ratio was 871 female births for every 1000 male births. We noted similar ratios irrespective of place of residence. Second-order births represented 27% of all births, and there was a striking deficit of nearly 30% in the adjusted sex ratio for female births after a previous female birth by comparison with a previous male birth, after which approximately equal numbers of boys and girls were born (table 1, figure 1); the pattern was similar for rural and urban areas. Third-order births represented 18% of all births; if the previous two children born were girls, the adjusted sex ratio was even lower than that noted for first-order and second-order births, and the urban ratio was significantly lower than the rural one ($p<0·0001$). Households with two girls reported about 20% higher absolute numbers of third births (6782) than did households to which boys had been born (5562). If the previous two births were male, the adjusted sex ratio for the third-order birth was 1176. Whereas if one boy and one girl had been born, the ratio was 908. Fourth-order or higher-order births represented 27% of all births. For these, the overall sex ratio was still biased against females. The overall ratio for all births was 899, with similar ratios in rural and urban areas (table 1). The overall absolute deficit of female births at all birth orders, assuming equal female and male births, was 4797 girls, or 7% of the expected female births ([133 738/2]–62 072). The absolute total of about 4797 missing

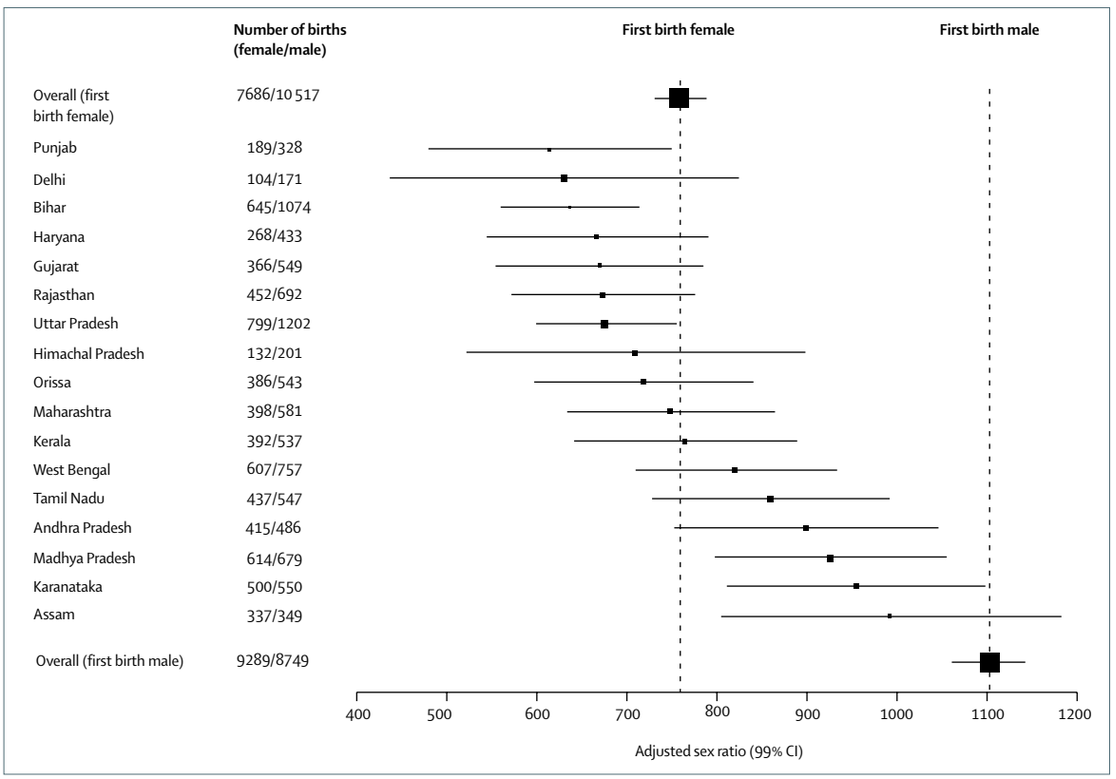

Figure 4: **Conditional sex ratio for second female births by state, 1997**
Sex ratios adjusted to SRS (1997) overall sex ratios at birth for each state and for India. Size of squares is proportional to square root of total births in that category and is normalised to total births for India.

females represents 37% of first-order, 29% of second-order, and 12% of third-order missing female births, respectively.

With respect to second-order births after a female birth, the more years of education the mother had the less likely they were to give birth to a girl; mothers with grade 10 or higher education had a significantly lower adjusted sex ratio (683, 99% CI 610–756) than did illiterate mothers (869, 820–917; $p<0\cdot0001$; figure 2). We noted no significant difference in adjusted sex ratios by religious group (Hindu, Muslim, or "other than Hindu and Muslim"; figure 3). All households, irrespective of religious affiliation, were less likely to have a second female child. Similar analyses for household ownership of agricultural land showed no major differences in sex ratios by amount of land owned (data not shown).

Table 2 shows the sex ratio for second-order births for the 16 major states and Delhi city, depending on whether the firstborn was a boy or a girl. Figure 4 presents the data for second female birth in major states by ascending sex ratio. For Delhi city and all states (except Assam) the sex ratio is lower when the previous child was female than when the previous child was male. Even states such as Kerala or Tamil Nadu, in which women are generally better educated and child-mortality rates are lower,[27] show clear differences between the sex ratio after a previous female birth versus a previous male birth.

The results of a multivariate analysis differed little from the simple adjusted sex ratios presented. The overall unadjusted odds reduction of a second female was 32% (99% CI 28–35). After adjustment for religion,

	Number			
	Female	Male	Total	Sex ratio (99% CI)
Stillbirth				
Overall	537	664	1201	809 (689–929)
Rural residence	445	549	994	811 (678–943)
Urban residence	92	115	207	800 (514–1086)
Early neonatal deaths				
Overall	1869	2304	4173	811 (747–876)
Rural residence	1691	2056	3747	822 (753–892)
Urban residence	178	248	426	718 (537–898)
All neonatal deaths				
Overall	2420	2952	5372	820 (762–877)
Rural residence	2199	2633	4832	835 (773–897)
Urban residence	221	319	540	693 (538–848)

Table 3: **Female-to-male ratio (per 1000) for stillbirths, early neonatal deaths (0–7 days), and all neonatal (0–28 days) deaths, by place of residence**

	Sex of previous children	Births in millions (% of all births)	Observed female births (millions)	Expected female births (millions)		Missing female births in millions (% of missing female births)	
				Female-to-male ratio		Female-to-male ratio	
				950	975	950	975
1	..	8·1 (29%)	3·8	3·9	4·0	0·17 (30%)	0·23 (31%)
2	Male	3·7 (13%)	1·9	1·8	1·8	..	...
	Female	3·8 (14%)	1·6	1·8	1·9	0·21 (36%)	0·23 (32%)
3	Male	1·2 (4%)	0·6	0·6	0·6	..	..
	Female	1·4 (5%)	0·6	0·7	0·7	0·10 (17%)	0·11 (15%)
	One male, one female	2·4 (9%)	1·1	1·2	1·2	0·03 (5%)	0·04 (6%)
⩾4	..	7·4 (27%)	3·5	3·6	3·7	0·08 (13%)	0·12 (17%)
All	..	28·0 (100%)	13·1	13·6	13·8	0·59 (100%)	0·74 (100%)

*Based on SFMS data.[26] †Second-order and third-order births that follow previous male births ignored, since girls born into households with only previous sons are unlikely to undergo sex selection.

Table 4: **Observed, expected, and missing female births in India (millions) in 1997 by birth order and accounting for sex of previous children**

residence, maternal and husband's age, education of mother and her husband, age at marriage, and state of residence, the odds reduction of a second female was 31% (28–35; Wald χ^2 319·25, $p<0·0001$).

Female infanticide after a livebirth is a poorly understood event in India for want of reliable data.[13,14] All pregnancies are tracked in the SRS, and nearly all births and neonatal deaths among those who do not move are recorded. Infanticide occurs early—typically on the first day after birth[13]—and would presumably be reported by the households as a stillbirth or early neonatal death. The total number of stillbirths reported (1201) does not account for the total number of missing second females (about 1500) or missing third females (about 600). Moreover, stillbirths and early (or all) neonatal deaths are more commonly reported to be boys (table 3) and none show the marked differences by education that we noted for second births after a first female birth (data not shown).

Discussion

Our findings indicate that, in India, the sex of a previous child or children born affects the sex ratio of the current birth, with fewer females born as second or third children to families who have yet to have a boy. We noted similar findings with respect to the sex ratio of second-order births in rural and urban areas, irrespective of religion, and in nearly all states studied.

Differences in the numbers sampled in the SRS and SFMS, might have led to a reporting of fewer female than male births. The deficit in the number of female births does not, however, explain the differences in the sex ratios we noted across states. And the noted shortfall in female births in families who already have girls is too extreme and much too consistent across residence, religious, or educational categories to be attributable to chance. Moreover, such under-reporting of female births might reduce the observed sex ratios, but should not affect the relative differences in sex ratios noted for conditional births. Finally, we noted the lower-than-expected sex ratio in both the SFMS and the SRS data. We believe, because of the large sample size and representative nature of the SRS, that our results are reliable.

One interpretation of our findings is that households are ensuring that at least one boy is born. The deficit in the number of girls born as second children is more than twice as great in educated than in illiterate mothers, assuming equal births. These differences noted for educational level are not correlated with income or measures of wealth, such as land holding. Nevertheless, we believe they indicate cultural preferences and easier access to, and greater affordability of, prenatal ultrasound in educated individuals.[19,23] Although further research is needed, in our opinion, the most plausible explanation for the low female-to-male sex ratios reported at birth is prenatal sex determination followed by selective abortion. Other explanations,[5–12] including infections, smoking, maternal nutrition, and hormonal factors during pregnancy, might play a part in reducing the overall sex ratios, but they are unlikely to explain the discrepancies noted for second-order and higher-order births. The results of a US study[29] of 6000 children born indicate that sex of subsequent births is independent of sex of earlier births. Moreover, these alternative explanations cannot readily explain the marked decline in female-to-male sex ratios recorded for children aged 0–6 years since the 1981 census, especially in urban areas.[1] In our survey, the differences in sex ratios between rural and urban areas were significant for third-order female births if the first two were also female. Reassuringly, female infanticide does not seem to be a major contributor to low sex ratios, although we could only measure this practice indirectly. Sex ratios at birth in China also appear to be driven more by selective abortion than by infanticide or under-reporting of female births.[30]

What might be the contribution of prenatal sex determination and selective abortion to the missing female births? Results of studies done in European, North American, Asian, and African countries suggest a natural sex ratio (that is, in the absence of selective medical or

social pressures for fewer females) of about 950–980.[3,25] Based on these figures, 13·6–13·8 million girls should have been born in India in 1997 (estimated total of girls and boys born being 28 million). The actual number, according to data from the SRS, was 13·1 million—a deficit of 0·59–0·74 million female births.

Our results suggest that prenatal sex determination and selective abortion probably account for nearly all of the deficit in the number of girls born as second or third children after previous female births. Depending on the expected sex ratios used, this figure totals 0·31–0·34 million (table 4; sum of numbers of relevant rows in last two columns). The biggest number of missing females (0·17–0·23 million fewer females than expected) arises in first-order births. We cannot directly estimate the degree to which prenatal sex determination affects sex ratio for the first child from our results. Biological ratios might favour fewer girls than boys for first births.[31] The adjusted sex ratio we noted for first births, however, seems too extreme to exclude selective abortion. Findings of other studies indicate that prenatal sex determination is used in first and second pregnancies,[18] even if families already have a son.[22] If we assume that selective abortion explains half the missing girls born first or girls born at third or higher birth order, that is a number of 0·14–0·20 million; a total of 0·45–0·54 million selective abortions yearly.

A much smaller national survey,[15,18] done at the same time as the SFMS, noted that 13% of women (8% of those living in rural areas and 31% of those living in urban areas) self-reported prenatal sex determination during their last pregnancy. Thus, at least 3·6 million (28 million×0·13) women have access to prenatal sex determination, of which about half—1·8 million—would be expected to be carrying female fetuses. If only one-third of these fetuses are aborted, then our calculations are not overestimates. Our findings are conservative when compared with those of the limited studies on ultrasound, abortion, and sex-selective abortion rates.[14–23] Finally, our study identifies that the women most clearly at risk of selective abortion are those who have already had one or two female children.

Our study is unable to comment on the consequences of missing female births in India. Increased risk of abortion-related maternal deaths is one such risk[18] and will be soon documented with the SRS.[32] Households wanting a boy might be expected to have more births. However, like others,[2] we find fertility rate marginally higher only for third births. Sex ratios at birth appear to correlate well with sex ratios at ages 0–6 years, suggesting that the oveall deficit in female children is driven by selective abortion. However, higher mortality rates among female than male children[2] also has a part to play (data not shown).

The long-term contribution of selective abortion of females to demographic imbalances between the sexes is poorly understood.[24,25] The United Nations Population Projections for India[3] use a static sex ratio, and could be underestimating the small, but profound distortion in female-to-male population structures at all ages. Anecdotal evidence from China, where restrictions on family size and prenatal sex determination use[30] contributed to a major imbalance in sex ratios, suggests that 40 million men are now unable to have spouses.[33] Reliable and long-term quantification of fertility and mortality and their correlates within the SRS is planned[32] and should help monitor future changes.

If we conservatively assume that prenatal sex determination and selective abortion accounts for 0·5 million missing female births yearly and that the practice has been common for most of the past two decades since access to ultrasound became widespread, then a figure of 10 million missing female births would not be unreasonable. Moreover, access to prenatal sex determination has probably increased in recent years throughout rural and urban India,[15,21,22] and fertility rates have dropped only slightly. The crude sex ratio at birth recorded in the SRS has fallen between 1997 and 2000–02 (from 899 to 892), with a decline twice as fast in urban (from 878 to 868) as in rural areas (from 903 to 898[27]). Thus the absolute numbers of missing females is likely to grow in the future.

Contributors

The Office of the Registrar General is responsible for the SRS design, data collection, and analyses. All authors assisted with statistical analyses, interpretation of data, and writing of the manuscript.

Conflict of interest statement

We declare that we have no conflict of interest.

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