The Effect of Ultrasound Testing during Pregnancy on Pregnancy Termination and the Sex Ratio at Birth in India

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Societal discrimination against women begins in our very homes. It begins even before the girl child is born. One of the most inhuman, uncivilized and reprehensible practices is the practice of female foeticide. The patriarchal mindset and preference for male children is compounded by unethical conduct on the part of some medical practitioners assisted by unscrupulous parents who illegally offer sex determination services.

No nation, no society, no community can hold its head high and claim to be part of the civilized world if it condones the practice of discriminating against one half of humanity represented by women. We are an ancient civilization and we call ourselves a modern nation. And yet, we live with the ignominy of an adverse gender balance due to social discrimination against women built into our societal structures….This is a national shame and we must face this challenge squarely here and now.

Dr. Manmohan Singh, Prime Minister of India, April 2008

INTRODUCTION

The traditional strong preference for sons in India is an enduring characteristic of the society (Jayaraman, Mishra, and Arnold, 2009; Das Gupta et al., 2003; Kishor and Gupta, 2009; Arnold, Kishor, and Roy, 2002; Mishra et al., 2004; Mari Bhat and Francis Xavier, 2003), although there are some indications that son preference is beginning to lose its grip at least in parts of the country (Das Gupta, Chung, and Shuzhou, 2009; International Institute for Population Sciences and Macro International, 2007).

The strong preference for sons has created a robust market for methods to determine the sex of fetuses. The easy availability of ultrasound testing for pregnant women in India during the last two decades has facilitated the expansion of sex-selective abortion. Sex-selective abortion in turn has resulted in abnormally high sex ratios at birth (males per 100 females), particularly in Punjab, Haryana, Gujarat, and Delhi. Legislation that makes it illegal for persons conducting ultrasound tests to reveal the sex of a fetus—the Pre-natal Diagnostics Techniques (Regulation and Prevention of Misuse) Act— came into force in 1996, but it has been remarkably ineffective in controlling the practice. However, much of the evidence related to this topic remains anecdotal. The limited availability of reliable information on the extent of ultrasound testing during pregnancy, the characteristics of pregnant women who undergo ultrasound testing, and the use of ultrasound for sex selection has seriously constrained research in these areas.

Because direct estimates of the extent of the practice of sex determination and subsequent abortion of female fetuses are not available, the research in this area has relied primarily on

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indirect methods of estimation based on reported sex ratios at birth. The 1998-99 National Family Health Survey (NFHS-2) was the first survey in India to collect nationwide data on the use of ultrasound and amniocentesis during pregnancies (International Institute for Population Sciences and ORC Macro, 2000). Although the survey did not ask whether these tests were done for sex determination purposes, the survey data made it possible to provide convincing evidence of the use of sex-selective abortions in many parts of India (Arnold, Kishor, and Roy, 2002). Based on NFHS-2, Mari Bhat and Francis Zavier (2007) estimated that 6 percent of female fetuses were aborted after a prenatal diagnostic test. However, they estimated that the proportion could be as high as 17 percent when possible underreporting is taken into account.

A community-based study in western Maharashtra interviewed 1,409 women who underwent induced abortion during 1996-98 and found that 18 percent of these abortions were for averting the birth of female babies (Ganatra, Hirve, and Rao, 2001). An analysis of 133,738 births from the Special Fertility and Mortality Survey in 1997 showed that the sex ratio at birth was 759 females per 1,000 males for the second birth when the preceding child was a girl and was 719 for the third birth if the first two children were girls. On the basis of the survey data, the authors estimated that there were 0.5 million "missing females" annually and more than 10 million missing females over the course of the previous two decades (Jha et al., 2006). However, the estimate of 10 million abortions of female fetuses was challenged by George (2006), Mari Bhat (2006), and others.

The current study uses more recent data from the third National Family Health Survey (NFHS-3) in India to examine the use and timing of ultrasound testing during pregnancy, pregnancy outcomes, and sex ratios at birth for women who had an ultrasound test during pregnancy and those who did not. The analysis also explores the determinants of ultrasound use and factors affecting the sex ratio at birth. A quantitative estimate is also made of the extent to which the use of ultrasound testing during pregnancy would be affected if there were no gender preference for children in India.

DATA AND METHODS

Data

This analysis is based on nationally-representative data from the 2005-06 National Family Health Survey, which was conducted under the stewardship of the Ministry of Health and Family Welfare, Government of India, and was coordinated by the International Institute for Population Sciences in Mumbai. Funding for NFHS-3 was provided by the United States Agency for International Development (USAID), the United Kingdom Department for International Development (DFID), the Bill and Melinda Gates Foundation, UNICEF, the United Nations Population Fund (UNFPA), and the Government of India. Technical assistance was provided by Macro International.

NFHS-3 covered all 29 states in India and interviewed 125,385 women age 15-49 and 74,369 men age 15-54 in 109,041 households. The analysis in this paper is based on 63,357 pregnancies to interviewed women in the five years preceding the survey.

Analysis

For each pregnancy, women in NHFS-3 were asked whether the pregnancy ended in a live birth or a non-live birth, whether the woman had an ultrasound test at any time during the pregnancy, and (for live births) the sex of the child. In this paper, the use of ultrasound and the sex of live births after an ultrasound test are examined in relation to a variety of demographic and socioeconomic variables including state of residence, urban-rural residence, education, religion, caste/tribe, the household wealth index, sex composition of living children at the time of the pregnancy, and utilization of antenatal care services. The data are analyzed using both descriptive statistics and multivariate logistic regression methods. The logistic regression models for the use of ultrasound during pregnancy and the sex of live births following an ultrasound test were estimated using SPSS.

RESULTS

Use of Ultrasound

Table 1 shows the percentage of all pregnancies in the five years preceding the NFHS-3 survey for which an ultrasound test was conducted at any time during the pregnancy. Overall, an ultrasound test was conducted for 24 percent of all pregnancies in the five years preceding the survey, but the overall estimate masks sizable differentials by geographic area and socio-demographic characteristics. The use of ultrasound was about twice as high for mothers who were less than 20 years old at the time of pregnancy (22 percent) and those age 20-34 years old (26 percent) as for mothers age 35-49 at the time of pregnancy (11 percent). However, only 4 percent of pregnancies in the five years preceding the survey were to mothers age 35-49. The use of ultrasound during pregnancy is much higher in urban areas (45 percent) than in rural areas (17 percent). As expected, ultrasound testing is rare for pregnancies to women who did not receive antenatal care (2 percent) and more substantial among women with 1-3 antenatal care visits (14 percent). Well over half of women with four or more antenatal care visits (58 percent) had at least one ultrasound test during the pregnancy.

The use of ultrasound increases dramatically with the mother's level of education and the wealth index. The use of ultrasound rises consistently from only 9 percent for women with no education to 66 percent for women with 12 or more years of education. Ultrasound testing ranges from 5 percent of pregnancies to women in the lowest wealth quintile to 63 percent of pregnancies to women in the highest wealth quintile. More than two-thirds of all ultrasound tests were conducted on women in the highest two wealth quintiles even though those women had only one-third of the total pregnancies. The use of ultrasound testing is similar for Hindus (24 percent)

Table 1 Ultrasound testing and pregnancy termination

Percentage of all pregnancies in the five years preceding the survey for which an ultrasound test was done and percentage of pregnancies with an ultrasound test that did not result in a live birth, according to background characteristics, NFHS-3, India, 2005-06

Background characteristic	Percentage of pregnancies with an ultrasound test	Number of pregnancies	Percentage of pregnancies with an ultrasound test that were terminated	Number of pregnancies with an ultrasound test
Mother's age at pregnancy				
<20	22.2	16,654	7.7	3,704
20-34	25.6	44,293	9.9	11,340
35-49	11.3	2,409	20.00	271
Residence				
Urban	45.0	16,610	9.3	7,477
Rural	16.8	46,747	9.8	7,838
Antenatal care visits[1]				
None	2.1	9,035	NA	NA
1-3	14.2	15,660	NA	NA
4+	57.6	14,667	NA	NA
Mother's education				
No education	8.8	31,008	10.9	2,727
<5 years complete	16.8	4,633	8.5	777
5-7 years complete	28.8	9,262	8.7	2,668
8-9 years complete	35.8	7,735	8.4	2,767
10-11 years complete	51.6	4,963	10.3	2,562
12 or more years complete	66.3	5,755	9.6	3,813
Religion				
Hindu	24.1	49,665	9.6	11,984
Muslim	20.8	10,776	9.9	2,243
Christian	37.4	1,255	8.5	469
Sikh	48.7	777	8.3	379
Buddhist/Neo-Buddhist	33.0	395	5.6	130
Jain	79.3	98	4.8	78
Other	7.1	334	13.3	24
Caste/tribe				
Scheduled caste	17.2	13,037	8.8	2,247
Scheduled tribe	10.2	5,886	10.0	602
Other backward class	23.2	25,533	9.6	5,925
Other	34.8	18,429	9.7	6,416
Wealth index				
Lowest	4.5	15,715	11.9	707
Second	10.2	13,994	10.1	1,429
Middle	21.5	12,561	8.3	2,705
Fourth	38.6	11,598	9.7	4,476
Highest	63.2	9,489	9.6	5,997

Continued…

Table 1 Ultrasound testing and pregnancy termination - *Continued*

Background characteristic	Percentage of pregnancies with an ultrasound test	Number of pregnancies	Percentage of pregnancies with an ultrasound test that were terminated	Number of pregnancies with an ultrasound test
Mother's number of living children at the time of pregnancy				
No children	36.7	20,908	9.4	7,665
1 child	27.6	17,836	7.2	4,919
0 sons	28.7	8,906	6.8	2,559
1 son	26.4	8,930	7.6	2,361
2 children	16.3	10,775	12.9	1,761
0 sons	22.8	3,163	11.6	722
1 son	14.5	5,320	13.9	771
2 sons	11.7	2,291	13.3	268
3 children	9.1	6,352	14.8	581
0 sons	16.6	1,184	9.7	196
1 son	8.8	2,677	20.5	235
2+ sons	6.0	2,491	12.5	150
4+ children	5.2	7,484	18.8	388
0 sons	11.7	595	7.6	70
1 son	7.1	1,818	23.0	129
2+ sons	3.8	5,071	20.0	190
Total	24.2	63,357	9.5	15,315

NA: Not available

[1] Includes only the most recent pregnancy ending in a live birth in the five years before the survey.

and Muslims (21 percent), but much higher for Jains (79 percent), Sikhs (49 percent), Christians (37 percent), and Buddhists/Neo-Buddhists (33 percent). Women from disadvantaged caste/tribe groups are much less likely than women from other groups to have ultrasound testing during pregnancy. Only 10 percent of women from scheduled tribes had an ultrasound test during their pregnancies, compared with 17 percent of women from scheduled castes, 23 percent of women from other backward classes, and 35 percent of women who do not belong to any of these groups.

The use of ultrasound testing declines sharply with parity, from 37 percent if the woman had no living children at the time of the pregnancy to only 5 percent if the woman already had four or more living children. Within each parity, ultrasound testing is most prevalent for women with no sons and decreases steadily with the number of living sons. The differential by the number of sons is smaller for women with one living child at the time of the pregnancy than for women with two or more children. Women at second and higher parities are about 2-3 times as likely to

have an ultrasound test if they have no sons than if they have two or more sons. The consistent and substantial differences in the use of ultrasound by women at the same parity with different numbers of sons and daughters provides clear evidence that sex determination of the fetus is an important reason for getting an ultrasound test.

Pregnancy outcome

For every pregnancy in the last five years, women in NFHS-3 were asked whether the pregnancy ended in a live birth (specifying whether the baby was a girl or a boy) or a non-live birth. However, the type of non-live birth was not determined so it is not possible to identify whether a pregnancy termination was due to a miscarriage, an induced abortion, or a stillbirth. Ten percent of pregnancies with an ultrasound test resulted in a pregnancy termination (Table 1). Older women (age 35-49) had the highest level of pregnancy terminations (20 percent). Pregnancy terminations were slightly elevated for women in the lowest wealth quintiles, for women with no education, and for women from scheduled tribes. Pregnancy terminations increase monotonically from 7 percent for women with one child to 19 percent for women who already have at least four children. At every parity, the percentage of pregnancies with an ultrasound test that were terminated was higher for those who already had at least one son than for those who had no sons. This result suggests a reluctance to abort a pregnancy if the woman does not have a living son. However, for women with two or more children, pregnancy terminations were higher for women with one son than for women with either no sons or two or more sons, suggesting some preference for at least one child of each sex.

Twelve percent of pregnancies that were not accompanied by an ultrasound test ended in a termination (data not shown). Differentials in pregnancy terminations by background characteristics are much larger among women without an ultrasound test during pregnancy than among women with an ultrasound test. Pregnancy terminations for women without an ultrasound test increase steadily with the woman's education, from 10 percent for women with no education to 28 percent for women with 12 or more years of education. A similar pattern is seen by wealth quintiles, ranging from 9 percent for women in the lowest wealth quintile to 27 percent for women in the highest wealth quintile. Since miscarriages and stillbirths are likely to be less common for women with high education and high income, it is likely that the high prevalence of pregnancy terminations in these groups is due to induced abortions. Since these groups have very low fertility preferences, they are more likely to terminate unintended pregnancies. Because the prevalence of terminations among pregnancies without an ultrasound test is somewhat lower for women without any sons than for those with at least one son, it is likely that women in different groups are employing stopping rules when they reach their desired number of sons and daughters. It is also possible that some of these women had an unreported ultrasound test that was followed by a sex-selective abortion. However, the analysis of sex ratios at birth in the next section does not support this supposition.

Sex ratios at birth

For live births, the overall sex ratio at birth (SRB) for children born in the five years before the survey was 108.8, which is higher than the normal biological range of about 103-107 (Johansson and Nygren, 1991). The SRB was 117.7 for women who had an ultrasound test during pregnancy, compared with 106.1 for women who did not have an ultrasound test. The latter sex ratio is within the normal biological range. Therefore, the elevated sex ratio of births in India appears to be entirely the result of ultrasound testing followed by sex-selective abortion. If nulliparous women are excluded from the calculation, the SRB for women with an ultrasound test rises to 127.2.

The widespread use of ultrasound for sex selection is evident from the fact that the SRB for pregnancies with an ultrasound test exceeds the normal biological range for mothers in urban and rural areas and for mothers in every age, education, caste/tribe, and wealth group (Table 2). The SRB for pregnancies with ultrasound is abnormally high for all religious groups except Muslims and Christians. By parity, the SRB for women with an ultrasound test during pregnancy increases from 109.0 for women without any living children to 121.7 for women with one child and 141.9 for women with two children. For women with three or more living children at the time of the pregnancy, the SRB exceeds 130. Within parities, the SRB varies dramatically by the sex of the woman's living children. At the first parity, the SRB is 141.5 for women whose only living child at the time of pregnancy was a daughter. For those with a son, the SRB is 103.3, which is toward the low end of the normal biological range. At the second parity, the SRB after an ultrasound test is 180.6 for those with no sons, 121.8 for those with one son and one daughter, and 115.8 for those with two sons. The extremely high SRB for women with two daughters and no sons indicates the substantial use of sex-selective abortion by women in that group. At higher parities, the SRB is also very high (more than 150) for women with no living sons.

Women without ultrasound tests should have a normal sex ratio at birth unless they are using another method of sex determination that is not as widely used in India such as amniocentesis or chorionic villus sampling. Since these other methods are more expensive than ultrasound and require more medical expertise to perform, they are used mainly by better educated and wealthier women. The 1998-99 National Family Health Survey (NFHS-2) asked a specific question about the use of amniocentesis during antenatal care visits and found that only 2 percent of women had amniocentesis during these visits for pregnancies in the three years before the survey (International Institute for Population Sciences and ORC Macro, 2000). The fact that the SRB for women without an ultrasound test during pregnancy in NFHS-3 is well within the normal biological range indicates that overall there is not a substantial use of alternative methods of sex selection and also that there is not a substantial amount of underreporting of ultrasound testing that results in sex selection.

Table 2 Sex ratio of live births with an ultrasound test during pregnancy

Percent distribution of the sex of live births for which an ultrasound test was conducted during pregnancy and sex ratio at birth, according to background characteristics, NFHS-3, India, 2005-06

Background characteristic	Sex of live birth			Live births with an ultrasound test during pregnancy	Sex ratio at birth (males per 100 females)
	Son	Daughter	Total percent		
Mother's age at pregnancy					
<20	52.12	47.88	100.00	3,419	108.9
20-34	54.76	45.24	100.00	10,221	121.0
35-49	51.97	48.03	100.00	217	108.2
Residence					
Urban	54.37	45.63	100.00	6,784	119.2
Rural	53.76	46.24	100.00	7,072	116.3
Mother's education					
No education	54.24	45.76	100.00	2,429	118.5
<5 years complete	53.13	46.87	100.00	711	113.4
5-7 years complete	53.35	46.65	100.00	2,435	114.4
8-9 years complete	53.37	46.63	100.00	2,536	114.5
10-11 years complete	55.68	44.32	100.00	2,297	125.6
12 or more years complete	54.06	45.94	100.00	3,448	117.7
Religion					
Hindu	54.59	45.41	100.00	10,836	120.2
Muslim	50.60	49.40	100.00	2,021	102.4
Christian	51.12	48.88	100.00	429	104.6
Sikh	58.53	41.47	100.00	347	141.1
Buddhist/Neo-Buddhist	63.64	36.36	100.00	123	175.0
Jain	52.23	47.77	100.00	74	109.3
Other	49.71	50.29	100.00	21	98.8
Caste/tribe					
Scheduled caste	53.62	46.38	100.00	2,049	115.6
Scheduled tribe	58.48	41.52	100.00	542	140.8
Other backward class	54.51	45.49	100.00	5,358	119.8
Other	53.58	46.42	100.00	5,792	115.4
Wealth index					
Lowest	53.73	46.27	100.00	623	116.1
Second	53.02	46.98	100.00	1,286	112.9
Middle	52.64	47.36	100.00	2,480	111.1
Fourth	53.92	46.08	100.00	4,044	117.0
Highest	55.10	44.90	100.00	5,424	122.7

Continued…

Table 2 Sex ratio of live births with an ultrasound test during pregnancy - *Continued*

Background characteristic	Sex of live birth			Live births with an ultrasound test during pregnancy	Sex ratio at birth (males per 100 females)
	Son	Daughter	Total percent		
Mother's number of living children at time of pregnancy					
No children	52.15	47.85	100.00	6,947	109.0
1 child	54.89	45.11	100.00	4,564	121.7
0 sons	58.60	41.40	100.00	2,384	141.5
1 son	50.82	49.18	100.00	2,180	103.3
2 children	58.66	41.34	100.00	1,535	141.9
0 sons	64.36	35.64	100.00	639	180.6
1 son	54.92	45.08	100.00	663	121.8
2 sons	53.67	46.33	100.00	232	115.8
3 children	56.62	43.38	100.00	495	130.5
0 sons	60.61	39.39	100.00	177	153.9
1 son	54.82	45.18	100.00	187	121.3
2+ sons	53.79	46.21	100.00	131	116.4
4+ children	57.85	42.15	100.00	315	137.2
0 sons	60.36	39.64	100.00	64	152.3
1 son	64.84	35.16	100.00	99	184.4
2+ sons	52.24	47.76	100.00	152	109.4
Total	54.06	45.94	100.00	13,857	117.7

However, there may be more use of amniocentesis or underreporting of ultrasound among particular subgroups. For example, for women who said they did not receive an ultrasound test during pregnancy, NFHS-3 found a particularly high SRB among women with 12 or more years of education (120.6), which is consistent with the extremely high percentage of pregnancies for this group that were terminated (28 percent) [data not shown]. However, only 3 percent of pregnancies that ended in a live birth were to mothers with 12 or more years of education, so the elevated SRB for that group has little impact on the overall SRB for all births. A few other groups also have high SRBs (births to women age 35-49, Sikhs, and Buddhists), but these groups are all quite small.

Timing of ultrasound testing

For pregnancies in the last five years, NFHS-3 asked whether an ultrasound test was performed at any time during the pregnancy, but not how many months pregnant the woman was when the ultrasound test was done. However, some information about the timing of ultrasound tests can be obtained by analyzing the ultrasound experience of currently pregnant women according to their

month of pregnancy. Table 3 shows the percentage of current pregnancies for which an ultrasound test was done broken down by the number of months pregnant and the sex composition of living children. Overall, 6-7 percent of women in their first three months of pregnancy have already had an ultrasound test. The proportion rises to 13-14 percent at 4-5 months of pregnancy and 20 percent in the sixth month of pregnancy. By the seventh month of pregnancy, ultrasound testing reaches 24 percent, which is the same as the average of all pregnancies in the last five years that have had an ultrasound test.

Table 3 Ultrasound testing by month of pregnancy

Percentage of currently pregnant women who report that they have had an ultrasound test during the pregnancy by number of months pregnant, NFHS-3, India, 2005-06

Number of months pregnant	Percentage receiving an ultrasound test during the pregnancy	Number of women
1	7.2	54
2	5.9	628
3	7.1	950
4	12.5	809
5	13.5	887
6	19.6	774
7	23.9	802
8	29.8	800
9	25.9	657
10	14.9	68

Abortions are currently legal in India up to only 20 months of gestation. Based on the NFHS-3 data on ultrasound testing for currently pregnant women by month of pregnancy, we can estimate that only about half of ultrasound tests are done that early in the pregnancy. This estimate is based on the ratio of the percentage of pregnancies in the fifth month with an ultrasound test to the weighted average of the percentage of pregnancies of 8-10 months' duration with an ultrasound test. This suggests that half of ultrasound tests in India are conducted too late in the pregnancy to qualify for a legal abortion. Although most abortions performed in India are thought to be illegal (Caldwell and Caldwell, 2003), illegal abortions after 5-6 months of pregnancy are not likely to be common. Therefore, it is evident that ultrasound tests after five months of pregnancy are overwhelmingly for diagnostic purposes and not for sex selection. Moreover, the percentage of women in the first three months of pregnancy who received an ultrasound test is about half of the percentage in the fourth and fifth month who were tested. Since ultrasound tests that are done too early in the pregnancy (less than 16-20 weeks) cannot

reliably detect the sex of the fetus and tests that are done too late may not be timely for arranging a safe abortion, it is expected that ultrasound tests that are done for the purpose of sex selection will be conducted in a relative short window of time between the fourth and fifth month of pregnancy. Based on the above logic, we find that only about one-quarter of all ultrasound tests are conducted at a pregnancy duration that would be optimal for determining the sex of the fetus and obtaining a safe sex-selective abortion if desired.

State differentials in the use of ultrasound testing

Although the number of pregnancies in the five years before the survey is too small in most states to do the detailed type of analysis conducted above at the national level, a clear picture emerges of the use of ultrasound in different parts of India and in the states with a strong preference for sons. The use of ultrasound during pregnancy is highest (ranging from 49% of pregnancies in Karnataka to 78% in Kerala) in the Southern Region, where son preference is relatively low. Use of ultrasound is also high in the Western Region (ranging from 36% in Gujarat to 75% in Goa) and most states in the Northern Region. Use of ultrasound is much higher than the national average in all of the states with the strongest preference for sons. However, it is important to note that only one state with very high use of ultrasound testing (Punjab) was identified in NFHS-3 as having a very strong son preference. All six of the states with the weakest expressed son preference in NFHS-3 (Tamil Nadu, Goa, Kerala, Karnataka, Himachal Pradesh, and Delhi) exhibit very high utilization of ultrasound testing—between 48 and 78 percent (International Institute for Population Sciences and Macro International, 2007).

Table 4 Pregnancies for which an ultrasound test was done

Percentage of all pregnancies in the five years preceding the survey for which an ultrasound test was done, according to state, NFHS-3, India, 2005-06

State	Percentage of pregnancies with an ultrasound test
North	
Delhi	52.8
Haryana	37.1
Himachal Pradesh	47.9
Jammu & Kashmir	34.8
Punjab	46.3
Rajasthan	18.0
Uttaranchal	23.7
Central	
Chhattisgarh	10.7
Madhya Pradesh	11.1
Uttar Pradesh	9.6
East	
Bihar	8.1
Jharkhand	9.6
Orissa	14.3
West Bengal	15.9
Northeast	
Arunachal Pradesh	18.9
Assam	9.2
Manipur	22.6
Meghalaya	16.1
Mizoram	10.7
Nagaland	10.1
Sikkim	34.2
Tripura	15.1
West	
Goa	75.4
Gujarat	35.8
Maharashtra	48.3
South	
Andhra Pradesh	52.7
Karnataka	48.9
Kerala	77.9
Tamil Nadu	52.3

Estimation of ultrasound use in the absence of sex preference for children

Although women were not asked why they had an ultrasound test, NFHS-3 data provide strong evidence that a large majority of ultrasound tests are for diagnostic monitoring of the pregnancy and not for the purpose of sex selection. Using a measure developed by Arnold (Arnold et al., 1998; Arnold, 1985), we estimate the extent to which utilization of ultrasound testing would change if there was no sex preference for children. The measure assumes that in the absence of sex preference, all women at a given parity would use ultrasound testing during pregnancy to the same extent as women at the same parity with the most desirable sex composition of children (that is, women with the lowest use of ultrasound testing at that parity). Under this assumption, the use of ultrasound testing would decrease because ultrasound testing that is currently performed solely for the purpose of sex determination would disappear. Applying this methodology to the NFHS-3 data, we find that the percentage of pregnancies for which an ultrasound test is done would decrease only slightly, from the actual level of 24.2 percent to a level of 22.9 percent if there were no sex preference in India. The relatively small difference is partly due to the fact that more than 60 percent of pregnancies are to women who have no children or one child. These are parities at which sex-selective abortion is not pronounced. The small calculated change provides further support for the observation that ultrasound during pregnancy in India is used primarily for diagnostics purposes, not for sex selection.

Calculation of percentage of ultrasound tests used for sex selection

If we assume that the sex ratio at birth in India would be in the middle of the normal biological range in the total absence of sex-selective abortion, then it is possible to estimate the percentage of *reported* ultrasound tests that are used for sex determination followed by sex-selective abortion. Alternative calculations are made under the two following assumptions:

A. Sex-selective abortions are used only to abort female fetuses

B. The number of sex-selective abortions of male fetuses is 20 percent as high as the number of sex-selective abortions of female fetuses

In both cases, we assume that the true biological SRB is 105.5 males per 100 females. The calculations below use the alternative definition of SRB that is used in India—the number of females per 1,000 males. Under this definition, the true biological SRB would be 947.8 females per 1,000 males [= (100/105.5)*1,000].

Calculation for scenario A

As mentioned earlier, in NFHS-3 the actual SRB for births in which the mother reported having an ultrasound test during pregnancy is 117.7 males per 100 females, which equals 849.6 females per 1,000 males under the Indian SRB definition. If *all* ultrasound tests were used to determine the sex of the fetus and *all* female fetuses detected were subsequently aborted, then the SRB for

live births would be 0 females per 1,000 males. On the other hand, if no ultrasound tests were used for sex determination or if no sex-selective abortions were carried out even if the sex of the fetus was known, then the SRB would be equal to the true biological SRB of 947.8. The extent to which the actual SRB of children born when the mother had an ultrasound test during pregnancy differs from the assumed biological SRB is an indicator of the use of ultrasound for sex selection. Since the actual SRB following an ultrasound test is 10.4 percent of the way between the biological SRB of 947.8 and the SRB of 0 if all female fetuses were detected and aborted, then we find that about 10 percent of all ultrasound tests in India are used for sex selection.

Of course, the results are quite different if we restrict the calculation to women with an ultrasound test who did not already have any sons when they got pregnant. The sex ratio of live births is 917.4 for women with no children, 706.7 for women with one daughter and no sons, 553.7 for those with two daughters and no sons, 649.8 for those with three daughters and no sons, and 656.6 for those with more than three daughters and no sons. The corresponding percentages of ultrasound tests used for sex selection in these cases are 3.2 percent for women with no living children, 25.4 percent at the first parity, 41.6 percent at the second parity, 31.4 percent at the third parity, and 30.7 percent at the fourth and higher parities. The reason that the overall percentage of women with an ultrasound test who had the test for sex-selection purposes is quite low (10.4 percent) is that only 24 percent of all women with an ultrasound test had at least one child but no sons at the time they became pregnant.

Calculation for scenario B

Because of the strong preference for sons in India, it is unlikely that many women would choose to abort a male fetus whose sex was detected through ultrasound. It is true that most women and men in India would like to have at least one girl among their children (74 percent of women and 65 percent of men according to NFHS-3). One reason that is often cited for the desire for a girl is the Hindu religious obligation of *kanyadan* (giving a daughter away at the time of marriage), which is one of the prerequisites for obtaining the highest level of merit. However, Muslim women and men are even more likely than Hindus to express a desire for at least one daughter, so other factors are clearly involved in the formation of fertility preferences. Nevertheless, there is no evidence that a substantial number of women abort a male fetus because they want a daughter.

If we assume that sex-selective abortions of male fetuses are one-fifth as high as sex-selective abortions of female fetuses, the proportion of ultrasound tests that are used for sex selection would increase only slightly to 12.4 percent, compared with 10.4 percent if there were no sex-selective abortions of male fetuses. Therefore, under either scenario it would still be true that the large majority of ultrasound tests are not used for sex-selection purposes.

Limitations of the calculations

Although the general conclusion of the above analysis is quite robust, there are several limitations that could affect the estimates. First, the normal biological SRB in India could be slightly higher or lower than the assumed SRB of 947.8. However, the use of any alternative assumption within the normal biological range will have only a minor impact on the final estimate. Second, some women who reported that they had an ultrasound test during pregnancy may not actually have had the test, but there is no reason to think that there would be a substantial number of these cases. Third, the determination of the sex of the fetus by the ultrasound test could be inaccurate. Fourth, it is possible that some unscrupulous doctors may purposely report that a male fetus is a female fetus if the doctor wants to make additional money by performing an abortion. There is some anectodal evidence of this practice, but it is certainly not widespread. Finally, this analysis is limited to *reported* ultrasound cases. If some women who said they did not have an ultrasound test actually had one and followed up with a sex-selective abortion, then a larger percentage of actual ultrasound tests could have been used for sex selection. However, the fact that that SRB is in the normal range for women who said they did not have an ultrasound test during their pregnancy indicates that this phenomenon cannot be very common. Finally, if some women who aborted a female fetus did not even report that they had that pregnancy, then the estimates of sex-selective abortions would be biased downward. However, even if some or all of these biases are present, it would still be the case that ultrasound tests are used for diagnostic purposes and not sex selection in a large majority of cases.

MULTIVARIATE ANALYSIS

This section presents the results of multivariate analyses of the determinants of the use of ultrasound testing during pregnancy and the factors that affect the sex ratio at birth. Table 5 shows the regression results for the use of ultrasound during pregnancy and Table 6 shows the regression results for the sex of live births resulting from pregnancies with an ultrasound test. The background characteristics in both tables that are included in the regressions as potential confounders are urban/rural residence, the mother's religion, the mother's caste/tribe, the mother's level of education, the household wealth index, and the mother's age at the time of the birth. The analysis was carried out for three groups based on geographical areas: (1) all 29 states together, (2) a group of three states that have a strong son preference (Punjab, Haryana, and Gujarat) and (3) a group of three states that have only a weak son preference (Andhra Pradesh, Karnataka, and Kerala). For each group of states, separate regressions were run for women with one living child, two living children, and three or more living children at the time of the pregnancy.

Table 5 shows that women with one or two children are much less likely to go for ultrasound testing in rural areas than in urban areas. In Punjab, Haryana, and Gujarat, rural women with three or more children are significantly more likely than urban women to get an ultrasound test

Table 5 Logistic regression analysis of the use of ultrasound testing

Adjusted odds ratios (OR) from logistic regression that an ultrasound test was conducted during completed pregnancies in the five years preceding the survey, NFHS-3, India, 2005-06

Background characteristic	One surviving child			Two surviving children			3+ surviving children		
	All India	Punjab, Haryana, Gujarat	Andhra Pradesh, Karnataka, Kerala	All India	Punjab, Haryana, Gujarat	Andhra Pradesh, Karnataka, Kerala	All India	Punjab, Haryana, Gujarat	Andhra Pradesh, Karnataka, Kerala
Residence									
Urban *(Ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Rural	0.70***	0.77*	0.85	0.66***	0.79	0.66*	1.09	3.10**	0.76
Religion									
Hindu *(Ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Muslim	1.00	0.67	1.08	1.06	1.01	0.87	1.06	0.37	0.77
Christian	1.63***	--	1.06	1.44	--	0.98	0.59	--	0.07*
Sikh	1.14	1.00	--	1.22	0.96	--	2.65*	--	--
Buddhist/Neo-Buddhist	0.99	--	--	0.98	--	--	1.51	--	--
Other	1.21	--	0.20*	0.91	--	--	0.85	--	--
Caste/tribe									
Scheduled caste *(Ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Scheduled tribe	0.79*	1.09	0.42***	0.87	1.95	1.02	1.31	0.56	3.76*
Other backward class	1.22**	1.31	0.82	1.03	1.01	1.66*	0.91	0.76	1.11
Other	1.13*	1.45*	1.14	1.20	1.65*	1.99**	1.32	1.29	1.32
Education									
No education *(Ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<5 years complete	1.32**	1.20	0.92	1.17	0.50	1.29	1.82***	1.32	5.13**
5-7 years complete	2.19***	1.73**	2.05***	1.57***	1.15	1.45	1.97***	0.71	3.14*
8-9 years complete	2.17***	1.85***	1.70***	1.72***	1.59	1.92**	1.64**	1.32	6.57***
9-10 years complete	3.14***	2.01***	2.57***	2.10***	1.03	2.53***	1.52*	0.95	32.78***
12+ years complete	3.19***	2.48***	3.15***	1.71***	2.26*	1.26	2.93***	0.65	10.10**
Wealth index									
Lowest *(Ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Second	1.72***	0.70	1.42*	2.05***	1.72	3.02**	2.68***	0.63	2.46
Middle	2.88***	1.59	2.11***	4.00***	3.23*	4.45***	5.44***	7.11**	4.81*
Fourth	4.32***	2.35*	2.79***	7.70***	5.60***	9.07***	10.02***	7.21**	11.54***
Highest	7.73***	4.70***	5.25***	11.14***	8.16***	16.0***	17.08***	19.43***	18.78***
Age at birth									
15-19 *(Ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20-24	1.04***	1.69*	1.11	1.11	1.25	2.45*	3.57	--	0.18
25-29	1.54***	1.86*	1.37*	1.25	1.18	2.56*	3.12	--	0.18
30+	1.90***	1.56	1.86**	1.25	0.75	2.30*	3.97	--	0.13
Sex composition of children									
At least one son *(Ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No sons	1.14***	1.09	1.00	1.85***	2.21***	0.93	2.34***	2.79***	1.42

*** p < 0.001; ** p < 0.01; * p < 0.05

Ref=reference category.

when they are pregnant. There is no significant relationship between religion and ultrasound testing in almost all cases, but caste/tribe is significantly related to ultrasound testing for women with one child. Ultrasound testing for women with one child is least prevalent among scheduled tribes and is most prevalent for women who are not members of scheduled castes or scheduled tribes. Ultrasound testing during pregnancy has a strong positive relationship with the mother's education and the wealth status of the household. Women with 12 or more years of education are typically about 2-3 times as likely to get an ultrasound test as women with no education. The gradient is even steeper in the case of household wealth quintiles. First-parity women in the

highest wealth quintile are almost eight times as likely as women in the lowest wealth quintile to have an ultrasound test (OR=7.7). The relationship is even stronger for women with two children (OR=11.1) and women with three or more children (OR=17.1). All nine regressions show a consistent positive effect of higher wealth on ultrasound testing. Age is a significant factor only for first-parity women and for second-parity women from states without high son preference.Since the primary focus of this paper is on the effect of gender preference on sex selection, the extent to which ultrasound testing is influenced by the sex of a woman's children assumes major importance. After adjusting for all of the above confounding factors, one would not expect ultrasound testing to be significantly related to the sex composition of previous children in a society in which there is no gender preference for children. In India, this is true only in the group of states with a weak preference for sons (Andhra Pradesh, Karnataka and Kerala). For India as a whole, the use of ultrasound is significantly higher at every parity for women who do not have a living son. The odds ratios are particularly high (2.2-2.8) for women with two or more surviving children in states with high son preference.

For women who underwent an ultrasound test during pregnancy and had a live birth, the sex ratio at birth provides crucial information about the use of sex-selective abortions. Table 6 examines the factors related to having a male birth after an ultrasound test. The regression analyses do not identify any confounding characteristics that have a consistent significant association with the sex of the child. However, all of the odds ratios for those with no sons (compared with those with at least one son) are greater than one, although five of the nine odds ratios are not statistically significant. At the national level, women with one or two living children are significantly more likely to have a boy if they do not already have a son (OR=1.4 and 1.5, respectively). At the first parity, women in the high son preference states are twice as likely to have a boy if their first child was a girl than if it was a boy. Even in the low son preference states, women with one daughter and no son are 37 percent more likely to have a son for their next child than are women who had one son and no daughter at the time they became pregnant.

Table 6 Logistic regression analysis of the outcome of live births

Adjusted odds ratios (OR) from logistic regression that a live birth following a pregnancy with an ultrasound test in the five years preceding the survey was a boy, according to selected background characteristics, NFHS-3, India, 2005-06

	One surviving child			Two surviving children			3+ surviving children		
Background characteristic	All India	Punjab, Haryana, Gujarat	Andhra Pradesh, Karnataka, Kerala	All India	Punjab, Haryana, Gujarat	Andhra Pradesh, Karnataka, Kerala	All India	Punjab, Haryana, Gujarat	Andhra Pradesh, Karnataka, Kerala
Residence									
Urban *(ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Rural	1.05	1.27	0.92	0.65**	0.98	0.42***	1.15	3.67	5.93*
Religion									
Hindu *(ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Muslim	0.89	0.63	0.98	0.65**	0.69	0.64	0.72	--	0.18
Christian	0.89	--	1.24	0.89	--	2.25	1.07	--	--
Sikh	1.25	0.81	--	1.70	1.35	--	2.68	1.99	--
Buddhist/Neo-Buddhist	3.42**	--	--	1.56	--	--	0.78	--	--
Other	0.66	--	1.20	0.86	--	--	1.73	--	--
Caste/tribe									
Scheduled caste *(ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Scheduled tribe	1.28	2.15	0.93	0.82	5.83	0.68	1.45	44.46	0.44
Other backward class	1.21*	1.61	0.94	1.05	1.69	1.02	0.93	5.68	1.31
Other	1.21*	1.48	0.84	0.85	1.71	0.79	1.26	13.17*	2.50
Education									
No education *(ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<5 years complete	1.11	1.25	0.86	0.90	0.54	2.26*	2.71*	4.89	2.71
5-7 years complete	0.91	1.00	0.68*	1.21	1.05	2.63**	1.51	1.90	1.47
8-9 years complete	0.94	0.87	0.78	1.23	1.05	3.61**	1.68	3.48	2.20
9-10 years complete	0.96	1.32	0.72	1.49*	0.49	5.19***	1.80	0.20	0.85
12+ years complete	0.93	1.27	0.77	1.08	1.11	1.19	2.59*	--	1.21
Wealth index									
Lowest *(ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Second	0.97	4.89	0.82	0.66	1.83	2.47	0.54	--	0.69
Middle	0.94	10.58*	1.02	0.81	8.93	1.95	0.70	--	0.40
Fourth	0.93	8.97*	0.99	0.61	7.13	1.69	0.86	--	3.57
Highest	1.13	12.55**	1.12	0.68	16.34*	1.26	1.46	--	3.67
Age at birth									
15-19 *(ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20-24	1.31*	1.86	1.32	0.37*	--	0.14*	--	--	--
25-29	1.35*	1.84	1.29	0.34**	--	0.16*	--	--	--
30+	1.12	2.89*	0.73	0.42*	--	0.13*	--	--	--
Number and sex composition of children									
At least one son *(ref)*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No sons	1.40***	2.00***	1.37**	1.46***	1.32	1.23	1.18	1.05	3.48

*** p < 0.001; ** p < 0.01; * p < 0.05
Ref=reference category.

CONCLUSIONS

The 2005-06 National Family Health Survey (NFHS-3) provides a rich source of data for studying the use and timing of ultrasound testing during pregnancy, pregnancy outcomes, and the sex ratio at birth of live births for women who had an ultrasound test and those who did not have an ultrasound test during their pregnancies in the last five years. The data provide a unique opportunity to produce quantitative estimates of the extent to which ultrasound tests are used for sex determination followed by sex-selective abortions. While the analysis confirms the importance of son preference in making decisions about whether or not to have an ultrasound test and whether to selectively abort a female fetus, the survey provides clear evidence that a large majority of ultrasound tests are used for diagnostic purposes and not selection. Only 24 percent of pregnant women in India have an ultrasound test at any time during the pregnancy, and we estimate that only 10.4 percent of those tests result in sex-selective abortions of female fetuses. Nevertheless, the use of sex-selective abortions is sufficiently common that it results in skewed sex ratios at birth that are outside the normal biological range of about 103-107 males per 100 females. The sex ratio at birth from NFHS-3 is 108.8 for all births in the five years before the survey, but is much higher (117.7) for births to women who report having an ultrasound test when they were pregnant. The sex ratio at birth is particularly high (180.6) for women with two daughters and no sons who got an ultrasound test during their pregnancy.

While son preference is no longer a prominent feature of life in every part of India, it remains deeply entrenched in states such as Punjab and Haryana. The situation may improve with a mix of innovative educational efforts and stringent enforcement of existing laws that prohibit the use of sex-determination tests during pregnancy, but in the short run, the country will have to cope with the panoply of adverse effects of son preference, including discrimination against girls, skewed sex ratios, the marriage squeeze resulting from a dearth of marriage-age women, and the further postponement of the achievement of the goals of universal education and gender equality.

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