Sex imbalance and socioeconomic status in India: a counterintuitive relationship

S V Subramanian[1], Sakthivel Selvaraj[2]

[1] Department of Department of Society, Human Development and Health, Harvard School of Public Health; [2] Department of Population and International Health, Harvard School of Public Health.

Correspondence to: S V Subramanian, Assistant Professor, Department of Society, Human Development and Health, Harvard School of Public Health, 677 Huntington Avenue, KRESGE 7th Floor, Boston, MA 02115-6096 USA (Email: svsubram@hsph.harvard.edu; Fax: 617-432-3123)

Abstract

Context: Sex imbalance in South Asia potentially represents failed human development. While this has received research attention, little is known on whether sex imbalance is concentrated in certain socioeconomic groups than others.

Objective: To investigate the association between socioeconomic status and child sex imbalance in India.

Design, Setting and Participants: Analysis of population-based nationally representative time series data for five years of households with one or more children under the age of 5. The sample sizes for the analyses were: 73487 (1983), 76799 (1987-88), 77511 (1993-94), 100121 (1999-00), and 99916 (2004-05). The household attributes of interest were household income and education.

Main Outcome Measure: Sex imbalance was measured as child female:male ratio, defined as number of females per 1000 males in children aged under-5. We additionally modeled the likelihood of being a male child, using the sex of the child in a household.

Results: There was inverse association between female:male ratio and household income, and education. In 2004-05, the ratio was substantially lower among richest quartile of households (882) as compared to the poorest (933). There were only 809 and 859 girls to every 1000 boys in households where the head or the spouse had a graduate education compared to 958 and 943 girls to 1000 boys in households where head or the spouse had no education, respectively. In adjusted regression models, the odds ratios of being a male child was 1.07 (95% CI 1.05-1.09) in the richest quartile of households, and 1.05 (95% CI 1.01-1.09) in the most educated households.

Conclusions: The counterintuitive association between sex imbalance and socioeconomic status suggest that improvements in economic growth and educational achievements alone are unlikely to normalize the sex imbalances in India. Targeted public policies are required to offset the prevailing anti-girl and pro-boy norms in Indian and other South Asian societies.

Introduction

The first Indian census, held in 1871, revealed an excess of 5.5 million males over females,[1] with a steady decline in the number of females has been observed over the last century.[2, 3] Amartya Sen, writing 120 years later, estimated a deficit of 37 million women in India, giving due visibility to the "missing women" of South Asia.[4] At the dawn of the 21st century, India remains a noticeably masculine society, with 933 females for every 1000 males,[5] and the corresponding ratio for ages 0-6 years was 927 girls for every 1000 boys.[6] Explanations to account for the female-deficit has been largely

attributed to excess female mortality in younger ages,[7, 8] due to gender-discrimination in intra-household allocation in health-related resources.[9-13] Intra-household gender discrimination, in turn, is seen to reflect the strong societal norm of "son-preference".[14-16] With a 35% increased mortality risk for girls aged 1-5 years,[17] this reasoning is compelling. Recently, prenatal sex determination,[18] followed by selective abortion of female fetuses,[19] is estimated to have led to abortion of 10 million female fetuses over the last two decades in India,[20] potentially intensifying the masculinity in sexes. While the overall sex imbalance has received substantial attention,[21] little is known on the extent to which the sex imbalance varies across household socioeconomic status (SES).

We examined the relationship between sex imbalance and household SES. Specifically, we analyzed the heterogeneity in under-5 female:male ratio in India between 1983-2005, across multiple domains of SES,[22] including income, education, caste, religion, urban/rural status, and state of residence. An understanding of the SES patterning in sex imbalance is likely to provide insights into the differential processes by which abnormal female:male ratios are produced. If sex imbalance is particularly acute in certain SES groups, this also facilitates development of targeted policy interventions.

Methods

Data

We used population-based nationally representative, time-series household survey data provided by the Indian National Sample Survey Organization (INSSO) for five most recent years: 1983, 1987-88, 1993-94, 1999-00, and 2004-05. Unlike the census, the unique strength of this survey is that it contains information on household socioeconomic status. The household sample size across the years ranged between ~120000-150000.[23] Table 1 provides the sample sizes used to calculate sex imbalance across different SES domains.

<<<**Table 1** about here>>>

Outcome

Sex imbalance was defined as number of females per 1000 males in children aged under-5 (child female:male ratio). Unlike overall female:male ratio, under-5 ratio is less likely to be confounded by selective migration; a component that can influence population sex ratios, besides sex-differentials in births and deaths.[24, 25] The under-5 age cut-off is also analogous to the age cut-offs for child mortality, which remains a major source of explanation for the low female:male ratio.

Socioeconomic correlates

SES was measured at the household level using multiple indicators. *Income* was based on consumption-based expenditure data,[24, 25] and was specified as quartiles. Household consumption expenditure is considered an appropriate proxy for income in developing economies, given the predominance of rural population and existence of non-monetary or in-kind wages.[24, 25] *Education* was measured in terms of years of education for the head of the household (typically male, but also includes female-headed

households) as well as the spouse of the head of the household (typically female). We grouped years of education using the following Indian educational benchmarks: Illiterate (no formal education); Primary (≤ 5 years); Secondary (6-12 years); and Graduate (≥13 years). *Caste* was based on the head of the household's self-identification as belonging to a Scheduled Caste, Scheduled Tribe, Other Backward Class, or Other Caste. Scheduled caste consists of castes that are lowest in the traditional Hindu caste hierarchy,[26] who historically have experienced substantial social and economic exclusion and disadvantage. Scheduled tribes comprise of ~700 tribes who tend to be geographically, and socio-economically isolated, with extreme levels of deprivation.[27] Other backward class is a diverse collection of "intermediate" castes; considered low in the caste hierarchy, but above scheduled castes. The "other" caste is the residual category enjoying the highest status in the caste hierarchy. Since other backward class was ascertained only since in 1990-00, and 2004-05, for the preceding years we considered the other caste and other backward class as one group. *Religious affiliation* was categorized into Hindu, Muslim, Christian, Sikh, and Others. *Urban/rural* status was based on whether the household is located in a census-defined urban or rural area.

Analysis

Child female:male ratio were calculated by grouping samples of under-5 (with appropriate weights) for each wave for the different socioeconomic markers (Table 1). This process was repeated for urban and rural areas. We additionally conducted a regression analysis to model the independent effects of household income and education on the probability of a child being male. We specified a binary response model (y , boy=1, girl=0) for each child of the form, $\pi : y \sim Bernoulli(1, \pi)$. The probability π was related to the set of predictors, X (income, education, caste, religion, residence, time, and state dummy variables) by a logit-link function as $\text{logit}(\pi) = \log\left(\frac{\pi}{(1-\pi)}\right) = \beta_0 + \beta X$. The linear predictor on the right-hand side of the equation consisted of a fixed part ($\beta_0 + \beta X$) estimating the adjusted coefficients for the predictor variables. For presentation and discussion, we used, $\exp(\beta)$, which is the effect of a unit increase in X on the odds ratio of being a male child.

Results

Child female:male ratio, in general, have remained low over the last 20 years (Figure 1). In 2004-05 was among the lowest that has been observed (926) over the last twenty years (Figure 1). Table 2 presents the female:male ratio for the five different time periods for ages for the different SES markers.

<<<**Figure 1** about here>>>
<<<**Table 2** about here>>>

Household Income

In 2004-05, child female:male ratio decreased with increasing income (Table 2). The ratio was substantially lower among households in the richest quartile of income

(882) as compared to the poorest (933) or the second poorest income quartile (976). The substantially low female:male ratio in the top two income quartiles of households (compared to those in the bottom two income quartiles) was consistently observed for all time periods (Table 2). The differential in female:male ratio between the poorest and the richest quartile was highest in 1999-00 (192) and lowest 2004-05 (52) with the average differential across all times being 98 more females in the bottom income quartile than the richest income quartile.

Education

An inverse association between child female:male ratio and education of the head of the household was observed. In households where the head of the household had a college degree, female:male ratio was 809, as compared to 958 in households where the head of the household had no formal education, in 2004-05. Education-based differences in female:male ratio was also observed across all time periods, with the differences being most pronounced in 1999-00 (176), followed by 2004-05 (149), with an average differential across all time periods being 111 less females in the highly educated households, compared to the least educated households. The inverse association was also observed when we consider education of the spouse of the head of the household. Female:male ratios were consistently lower in households where the spouse (woman) was a graduate or had secondary education compared to women with no education or only primary education. In 2004-05 there were only 859 girls to every 1000 boys in households where the woman had a graduate education compared to 943 girls to 1000 boys in households where woman had no education.

Caste

On average, across the five time-periods, the socially advantaged caste had 43 fewer females, compared to scheduled tribes; a group which had the highest female:male ratio across all time periods, with the exception of 2004-05. Scheduled castes had the highest female:male ratio in 2004-05 (988). In 1999-00 the caste-based differentials were 107, with the female:male ratio for scheduled tribes being 1016 and 909 for the advantaged caste groups. The low female:male ratio ranged between 903 in 2004-05 and 935 in 1983 for the advantaged caste groups.

Religion

Sikhs have the lowest female:male ratio, regardless of the time period; in 2004-05 there were only 780 girls per 1000 boys. Hindu households also had lower female:male ratios when compared to Christian households, who have the highest female:male ratio among the major religious groups. In 2004-05, while the female:male ratio was 928 in Hindu households, it was 993 in Christian households. The female:male ratio in Muslim households was also higher than those observed for Hindu households, with the exception of 2004-05.

Urban/Rural status

The rural-urban differential in 2004-05 and 1999-00 were among the largest. In urban households, in 2004-05, there were 873 girls for every 1000 boys as compared to 941 girls for every 1000 boys in rural households, with similar differentials observed in

1999-00. Female:male ratio in urban households were consistently lower compared to rural households, with the average female:male ratio differential across all time periods being 35 between rural and urban households.

Table 3 presents the child female:male ratio for income and education, stratified by urban and rural area of residence. The inverse relationship between female:male ratio and household income and education is consistent *within* both urban and rural areas, with richer or more educated households, on average, having lower female:male ratio, and across time periods. In 2004-05, rural households in the top income quartile had a female:male ratio of 909, compared to 936 in the poorest income quartile. The corresponding differential in the urban households was 816 and 917 girls for 1000 boys in the richest and poorest quartile, respectively. The education-based differences in female:male ratio were even larger. Female deficit was markedly pronounced in urban households with highest education (805 girls for 1000 boys) compared to those with no education (917 girls for 1000 boys). Rural households with no formal education had a female:male ratio of 963, while those with college or more education had a female:male ratio of 815.

<<<**Table 3** about here>>>

Table 4 presents the results of a logistic regression analysis modeling the likelihood of a child being male as function of independent household attributes. Adjusting for caste, religion, time, and state fixed-effects, in the richest quartile of households the odds ratios of being a male child was 1.07 (95% CI 1.05-1.09), with the association between household income and the odds of being a male child being linear and positive (Figure 2(a)). Education of the head of the household was also a positive predictor of the likelihood of being a boy (Figure 2(b)). The odds ratio of being a male child was 1.05 (95% CI 1.01-1.09) when the head of the household's educational level was graduate or higher. The relationship between the likelihood of being a male child and education of the spouse (woman) of the head of the household was also positive but was not statistically significant (Table 4).

<<<**Table 4** about here>>>
<<<**Figure 2** about here>>>

Even after adjusting for household demographic and socioeconomic variables, the likelihood of being a boy substantially varied across Indian states (Figure 3). Using Kerala as a reference, the odds of having a boy was highest in Punjab (OR 1.18, 95% CI 1.12-1.25) followed by Haryana (OR 1.14, 95% CI 1.08-1.21). All the states had a higher likelihood of having a boy when compared to Kerala.

<<<**Figure 3** about here>>>

Discussion

Using a large, nationally representative, population-based time series data, we found a consistent inverse association between SES and child female:male ratio in India,

such that low female:male ratio are found to be largely concentrated in the high SES groups. First, high income and high education are strongly associated with low female:male ratio in India. Second, the inverse association between income or education and female:male ratio is consistent across time periods. Third, the patterning of high income or high educated households having, on average, low female:male ratio is observed within rural and urban areas. Fourth, there exists an independent influence of household income and education on the likelihood of a child being male, even after accounting the likely socio-cultural confounders to the association between SES and the likelihood of being a male child. To our knowledge, this is the first comprehensive examination of the socioeconomic impact on sex imbalance.

The observed counter-intuitive association between child female:male and SES can be potentially explained using a gender-inequity perspective, which in the context of South Asian societies such as India can be substantial. Gender inequities, meanwhile, can be considered in two ways: the presence of a *dormant* anti-girl view among low SES groups; or/and the presence of an *active* pro-girl view among the low SES groups.[28] Conversely this can also be stated as the presence of an *active* pro-boy view among high SES groups.

The inverse association between SES and female:male ratio could exist because the anti-girl views are dormant in low SES households as compared to high SES households. High SES households, since they possess the resources to reduce the burden of child mortality and morbidity, may tend to favor boys than girls. On the other hand, low SES households, with considerably fewer resources, carry a substantially overall higher morbidity and mortality burden. Put simply, the low SES households may not possess sufficient resources to practice substantial discrimination. The heightened anti-girl behavior with increasing SES seems consistent with existing studies. For instance, during the nineties, which was characterized by rapid economic growth, nutritional status improved for both sexes, but boys improved at a faster rate than girls.[29] The dormant anti-girl view is equally consistent with explanations based on selective abortion of female fetuses.[19, 20, 30, 31] Low SES households, with reduced physical and economic access to the medical technologies available for detecting the sex of the fetus, are less likely to participate in the high SES behaviors of practicing sex-selective abortion.[32] In a study based in Punjab, sex had been determined pre-natally for 5 of 236 girls (2%) and 49 of 360 boys (14%).[33] The lower prevalence of fetal sex determinations for girls is strongly suggestive of the result of the abortion of fetuses found to be female. Crucially, the use of fetal sex determination increased with increasing monthly income.[33]

Another gender-equity based explanation (though not necessarily mutually exclusive to the dormant anti-girl view) to account for the higher female:male ratio among low SES households could be because, economic and social value of a girl child may be an inverse function of SES leading to a weaker anti-girl practices in low SES households.[28] Evidence suggests that son-preference is greater among high SES households due plausibly to higher incidence of dowry marriages, lower female labor participation,[34] and prevailing inheritance practices favoring son.[8, 35] Sex imbalance is more adverse, for instance, among rural landed households;[28] reflecting the practice of

inheritance of property to sons rather than daughters.[36] The higher female labor participation in low SES households could also account for the low sex imbalance. Higher female labor participation may have positive externalities such as raising the returns to investment in girl children, lowering dowry levels, enhancing women's status in society, empowering women in household decision making; all these in turn leading to a potential increase in the economic and social value of the girl child.[34, 37] The actual as well as perceived worth of girl children in low SES households, therefore, could be higher due to higher levels of female labor participation, leading to diminished preference for sons, translating to lower sex imbalance.[38] Conversely, the higher sex imbalance in high SES households could be a reflection of the intense son-preference among such households.

Other secondary explanations to account for SES-based differential in female:male ratio could be due to the differences in lifestyles and behaviors in low and high SES groups. For instance, parental peri-conceptional smoking has been shown to produce a higher female:male ratio of offspring.[39] Female:male ratio has been shown to be higher when either one or both of the parents smoked more than 20 cigarettes per day compared to where neither of the parents smoked.[39] This explanation is consistent with our findings that lower income households have higher female:male ratio, as it has been shown that smoking prevalence is 25% in the poorest households compared to 10% in the richest households.[40] It has also been suggested that lower female:male ratio among high SES may be due to a sex-neutral reduction in "fetal wastage" (*i.e.*, spontaneous abortions and stillbirths).[41] This hypothesis postulates that nutritional improvements in maternal well-being will reduce the fetal wastage in sex-equal terms leading to low female:male ratio at birth.[42-44] High SES households, due to higher levels of nutrition,[45] and therefore greater levels of gender-neutral reduction in fetal wastage, may exhibit lower female:male ratio compared to low SES households. The nutrition-based biological explanation does not, however, seem consistent with evidence that suggest, for instance, the *declining* proportion of male births in Western industrialized nations,[46] that on average are better nourished. Explanations to account for the overall lower female:male ratio in India have also been linked to presence of diseases. It has been shown that Hepatitis B carriers are more likely to give birth to boys than girls.[47] It is however not clear how this might the explain the lower female:male ratio for the high income groups, unless the high income groups are disproportionately more likely to be hepatitis B carriers as compared to lower income groups.

Our findings need to be considered alongside the following caveats. We considered the under-5 "population" female:male ratio, as opposed to the more direct measure of female:male ratio at birth. In the absence of manipulation, typically, offspring ratio at birth favors males.[7] Reliable and comparative figures for female:male ratio at birth are difficult to obtain because of inadequacy of vital statistics registration, especially in India.[19, 21] In the absence of gender-inequalities in nutrition and health care, and given that men have a higher risk of premature mortality due to greater tendency to engage in risk behaviors,[48] females have lower mortalities across all age groups,[4] leading to a population ratio that favors females. Thus, any deviation in population female:male ratio from this pattern is a marker of "abnormal" offspring ratio. We also used sample

surveys to estimate under-5 female:male ratio, as opposed to the estimating these from the census. This potentially introduces issues related to sampling variability and reliability. However, it is impossible to investigate the distribution of under-5 female:male ratios across income and education as income is not ascertained by the Indian census, and census does not tabulate the under-5 population by sex and the education of the head of the household limiting our ability to use the census.

The counterintuitive association between sex imbalance and SES raises special public policy concern. That income alone, in the absence of education, may facilitate a deepening of the anti-girl perspective (especially through perverse use medical technologies) is clear. However, the robust inverse association between education and female:male ratio raises challenging concerns for public policy on human development. Education is an intrinsic aspect of human development, and potentially a catalyst for social progress and on matters related to mitigating gender-inequalities the role of education has received considerable attention.[37, 38, 49-54] Meanwhile, education, from a more traditional public policy perspective, is mainly regarded as an input for economic growth.[55 56, 57] Our finding that the problem of sex imbalance is particularly concentrated and acute in the more educated households is suggestive of the failure of education in transforming societal norms related to son-preference. Such a failure is a possible reflection of the public policy perspectives that inform education in India which primarily views education as a factor of production to economic growth, and as such may be reflected in the content and quality of education. Such a "human capital" perspective of education is likely to intensify in the current circumstances where there is a strong need to sustain the high levels of recent economic growth in India leading to perhaps an even greater sex imbalance.

The abnormality in the proportion of sexes in India, with substantially lower number of females, potentially represents failed human development. The problem of "missing girls" plagues at least half of the global population (India, China and other South Asian societies). The evidence presented in this study suggests that mere improvements in economic growth and educational achievements alone are unlikely to normalize the sex imbalance in India. Legislative measures,[58] accompanied by stringent enforcement, public awareness campaigns about the grim consequences of sex imbalance, is required to offset the prevailing anti-girl or pro-boy norms in South Asian societies.

Acknowledgments

S V Subramanian is supported by the National Institutes of Health Career Development Award (NHLBI 1 K25 HL081275). We acknowledge the support of National Sample Survey Organization for providing us access to the data for various time periods.

Contributions

S V Subramanian conceived the study, and led the analysis, interpretation and writing of the manuscript. Selvaraj Sakthivel contributed to the data analysis, interpretation and writing of the manuscript. Both authors reviewed and approved the final manuscript.

References

1. Natarajan D. *Changes in sex ratio.* New Delhi: Census of India; 1972.

2. Mayer P. India's falling sex ratios. *Population and Development Review.* 1999;25(2):323-343.

3. Miller BD. *The endangered sex: neglect of female children in rural north India*. Ithaca: Cornell University Press; 1981.

4. Sen A. Missing women. *Bmj.* Mar 7 1992;304(6827):587-588.

5. India Co. *Populations Totals - Table 00-003 (Population by sex and sex ratio).* New Delhi: Government of India; 2001.

6. India Co. *Populations Totals - Table 00-004 (Population by sex and sex ratio).* New Delhi: Government of India; 2001.

7. Coale AJ. Excess female mortality and the balance of the sexes in the population: an estimate of the number of "missing females". *Population and Development Review.* 1991;17:517-523.

8. Kishor S. Gender differentials in child mortality: a review of the evidence. In: Das Gupta M, Chen LC, Krishnan TN, eds. *Women's health in India: risk and vulnterability*. Bombay: Oxford University Press; 1995:19-54.

9. Basu AM. Is discrimination in food really necessary for explaining sex differentials in childhood mortality? *Population Studies.* 1989;43:193-210.

10. De Rose L, Das M, Millman SR. Does female disadvantage mean lower access to food? *Population and Development Review.* 2000;26(3):517-547.

11. Omvedt G. Women and rural revolt in India. *Journal of Peasant Studies.* 1978;5(3):370-403.

12. Osmani S, Sen A. The hidden penalties of gender inequality: fetal origins of ill-health. *Econ Hum Biol.* Jan 2003;1(1):105-121.

13. Khanna R, Kumar A, Vaghela JF, Sreenivas V, Puliyel JM. Community based retrospective study of sex in infant mortality in India. *Bmj.* Jul 19 2003;327(7407):126.

14. Das Gupta M. Selective discrimination against female children in rural Punjab, India. *Population and Development Review.* 1987;13:77-100.

15. Croll E. *Endangered Daughters- Discrimination and Development in Asia*. New York: Routledge; 2000.

16. Das Gupta M. Explaining Asia's Missing Women": A New Look at the Data,". *Population and Development Review.* 2005;31(3):529-535.

17. Subramanian SV, Nandy S, Irving M, Gordon D, Lambert H, Davey Smith G. The mortality divide in India: the differential contributions of gender, caste, and standard of living across the life course. *Am J Public Health.* May 2006;96(5):818-825.

18. Kulkarni S. Sex determination tests in India: a survey report. *Radical Journal of Health.* 1986:1:99.

19. Sen A. Missing women--revisited. *Bmj.* Dec 6 2003;327(7427):1297-1298.

20. Jha P, Kumar R, Vasa P, Dhingra N, Thiruchelvam D, Moineddin R. Low female[corrected]-to-male [corrected] sex ratio of children born in India: national survey of 1.1 million households. *Lancet.* Jan 21 2006;367(9506):211-218.

21. Hesketh T, Xing ZW. Abnormal sex ratios in human populations: causes and consequences. *Proc Natl Acad Sci U S A.* Sep 5 2006;103(36):13271-13275.

22. Braveman PA, Cubbin C, Egerter S, et al. Socioeconomic status in health research: one size does not fit all. . *JAMA.* 2005;294:2879-2888.

23. India Go. *Sample Design and Estimation Procedure, Employment-Unemployment Situation in India.* New Delhi: National Sample Survey Organisation, Ministry of Statistics and Programme Implementation; 2006. Part-1, September, B/1 – B/9.

24. India Go. *National Human Development Report 2001.* New Delhi: Planning Commission, Government of India; 2002.

25. Deaton A. Counting the World's Poor: Problems and Possible Solutions. *World Bank Research Observer.* 2001;16(2):125-147.

26. Chitnis S. Definition of the terms scheduled castes and scheduled tribes: a crisis of ambivalence. In: Pai Panandiker VA, ed. *The politics of backwardness: reservation policy in India*. New Delhi: Centre for Policy Research; 1997.

27. Subramanian SV, Smith GD, Subramanyam M. Indigenous Health and Socioeconomic Status in India. *PLoS Med.* Oct 24 2006;3(10).

28. Dubey A, Verschoor A. Does intra-household discrimination account for the bulk of India's "missing women"? Vol Unpublished; 2006.

29. Tarozzi A, Mahajan D. Child nutrition in India in the nineties. *Economic Development and Cultural Change.* 2007;55(3):441-486.

30. Agnihotri SB. Survival of the girl child: tunnelling out of the Chakravyuha. *Economic and Political Weekly.* 2003(October 11):4351-4360.

31. Hatti N, Sekher TV, Mattias L. *Lives at Risk. Declining Child Sex Ration in India.* Lund, Sweden: Department of Economic History, Lund University; 2004.

32. Kundu A, Sahu MK. Variation in the sex ratio: development implications. *Economic and Political Weekly.* 1991;26(41):2341-2342.

33. Booth BE, Verma M, Beri RS. Fetal sex determination in infants in Punjab, India: correlations and implications. *Bmj.* Nov 12 1994;309(6964):1259-1261.

34. Agnihotri S, Palmer-Jones R, Parikh A. Missing women in Indian districts: a quantitative analysis. *Structural Change and Economic Dynamics.* 2002;13(3):285-314.

35. Kishor S. "May God Give Sons to All": gender and child mortality in India. *American Sociological Review.* 1993;58(2):247-265.

36. Krishnaji N. Poverty and sex ratio: some data and speculations. *Economic and Political Weekly.* 1987;22:892-897.

37. Murthi M, Guio A-C, Dreze J. Mortality, fertility and gender bias in India: a district-level analysis. *Population and Development Review.* 1995;21(December):745-782.

38. Basu AM. *Culture, the Status of Women, and Demographic Behaviour*. Oxford: Clarendon Press; 1992.

39. Fukuda M, Fukuda K, Shimizu T, Andersen CY, Byskov AG. Parental periconceptional smoking and male: female ratio of newborn infants. *Lancet.* Apr 20 2002;359(9315):1407-1408.

40. Subramanian SV, Nandy S, Kelly M, Gordon D, Davey Smith G. Patterns and distribution of tobacco consumption in India: cross sectional multilevel evidence from the 1998-9 national family health survey. *BMJ.* Apr 3 2004;328(7443):801-806.

41. Jayaraj D, Subramanian S. Women's Wellbeing and the Sex Ratio at Birth: Some Suggestive Evidence from India. *The Journal of Development Studies.* 2004;40(5):91–119.

42. Bhat MPN. On the trail of "missing" Indian females I: Search for clues. *Economic and Political Weekly.* 2002;37(51):5105-5118.

43. Bhat MPN. On the trail of "missing" Indian females II: Illusion and reality. *Economic and Political Weekly.* 2002;37(52):5244-5263.

44. Klasen S, Wink C. A turning point in gender bias in mortality? an update on the number of missing women. *Population and Development Review.* 2002;28(2):285-312.

45. Subramanian SV, Smith GD. Patterns, distribution, and determinants of under- and overnutrition: a population-based study of women in India. *Am J Clin Nutr.* Sep 2006;84(3):633-640.

46. Davis DL, Gottlieb MB, Stampnitzky JR. Reduced ratio of male to female births in several industrial countries: a sentinel health indicator? *Jama.* Apr 1 1998;279(13):1018-1023.

47. Oster E. Hepatitis B and the Case of the Missing Women. *Journal of Political Economy.* 2005;113(6).

48. Waldron I. Recent trends in sex mortality ratios for adults in developed countries. *Soc Sci Med.* Feb 1993;36(4):451-462.

49. Anand S, Sen AK. Concepts of Human Development and Poverty: A Multidimensional Perspective. In: UNDP, ed. *Human Development Papers, Poverty and Human Development*. New York: HDRO, The United Nations Development Programme; 1997:1-19.

50. Dreze J, Sen AK. *India: economic development and social opportunity*. New Delhi: Oxford University Press; 1995.

51. Hammad AEB. Functional Literacy, Health and Quality of Life. *Annals of the American Academy of Political and Social Science.* 1992;520:103-120.

52. Dasgupta M. Death clustering, mothers' education and the determinants of child mortality in rural Punjab, India. *Population Studies.* 1990;44(November):489-505.

53. Ramachandran VK. On Kerala's development achievement. In: Dreze J, Sen AK, eds. *Indian development: selected regional perspectives*. Delhi: Oxford University Press; 1997:205-356.

54. Dreze J, Murthi M. Fertility, education, and development: evidence from India. *Population and Development Review.* 2001;27(March):33-64.

55. Schultz TP. Education Investments and Returns. In: Chenery H, Srinivasan TN, eds. *Handbook of Development Economics.* Vol 1. Amsterdam: Elsevier; 1989:543-630.

56. Dreze J, Saran M. Primary education and economic development in China and India: overview and two case studies. In: Basu K, Pattanaik P, Suzumura K, eds. *Choice, welfare and development*. Oxford: Clarendon Press; 1995:182-241.
57. Datt G, Ravallion M. *Why have some Indian states have done better than others at reducing rural poverty?* Washington DC: The World Bank; 1996.
58. India Go. Centre for Enquiry into Health and Allied Themes (CEHAT) and others v/s Union of India and others. *Law Journal Supreme Court Cases.* 2001;5:577-580.

Table 1 Sample sizes for calculating the child female:male ratio for five time periods by household socioeconomic status (SES)

	2004-05	1999-00	1993-94	1987-88	1983
Total	73487	76799	77511	100121	99916
Income Quartiles					
Poorest	20714	26933	26577	32415	31242
Second poorest	19128	20756	20965	27189	26935
Second richest	16926	16896	17054	23045	23489
Richest	16719	12214	12915	17472	18250
Education (Head)					
Illiterate	25420	30628	32611	44886	47557
Primary	20836	20464	22192	31607	29991
Secondary	22924	21303	19262	20830	19275
Graduate	4307	4404	4111	4303	3303
Education (Spouse)					
Illiterate	36599	42642	46120	63096	64273
Primary	14365	13202	13375	17071	16278
Secondary	12599	11144	9364	9162	7889
Graduate	1763	1931	1576	1486	1189
Caste					
Scheduled Tribe	9747	9577	8694	12381	11262
Scheduled Caste	13041	13492	13092	16223	16229
Other Backward Class	29333	26432	-	-	-
Other Caste	21366	27298	56390	73022	72635
Religion					
Hindu	54524	57516	60135	76895	76506
Muslim	11326	12547	10907	15595	14983
Christian	4279	3489	3722	4533	4502
Sikh	1677	1620	1675	2286	2290
Other	1681	1621	1737	2291	1837
Residence					
Rural	51161	52221	52956	71728	70028
Urban	22326	24578	25220	29898	30098

Note: Other Caste in 1993-94, 1987-88 and 1983 includes Other Castes and Other Backward Class.

Table 2 Child female:male ratio for five time periods by household socioeconomic status (SES)

	2004-05	1999-00	1993-94	1987-88	1983
Total	926	936	923	922	936
Income Quartiles					
Poorest	933	1004	953	943	971
Second poorest	976	910	941	917	945
Second richest	887	918	872	914	907
Richest	882	812	854	878	889
Education (Head)					
Illiterate	958	972	950	934	937
Primary	931	936	911	918	949
Secondary	894	896	883	902	929
Graduate	809	795	884	866	842
Education (Spouse)					
Illiterate	943	964	928	929	942
Primary	922	912	905	897	946
Secondary	852	843	895	934	897
Graduate	859	777	880	821	902
Caste					
Scheduled Tribe	913	1016	979	938	949
Scheduled Caste	988	945	945	910	938
Other Backward Class	914	934			
Other Caste	903	909	910	923	935
Religion					
Hindu	928	926	922	920	937
Muslim	919	1006	931	929	944
Christian	993	936	960	1032	923
Sikh	780	771	900	808	838
Other	1015	963	907	966	971
Residence					
Rural	941	951	929	922	938
Urban	873	881	900	922	932

Note: Other Caste in 1993-94, 1987-88 and 1983 includes Other Castes and Other Backward Class.

Table 3 Child female:male ratio for five time periods by household income and education for urban and rural households

RURAL	2004-05	1999-00	1993-94	1987-88	1983
Income Quartiles					
Poorest	936	1011	952	941	972
Second poorest	997	929	939	914	943
Second richest	898	943	881	905	898
Richest	909	825	851	886	887
Education (Head)					
Illiterate	963	974	951	933	937
Primary	954	957	915	912	954
Secondary	897	903	879	896	926
Graduate	815	833	981	913	748
Education (Spouse)					
Illiterate	951	965	928	928	940
Primary	917	922	909	886	961
Secondary	879	880	914	971	891
Graduate	1052	773	720	820	1023
URBAN					
Income Quartiles					
Poorest	917	978	969	964	967
Second poorest	898	843	948	932	956
Second richest	856	828	854	936	932
Richest	816	772	856	868	891
Education (Head)					
Illiterate	917	954	947	936	939
Primary	841	858	896	942	932
Secondary	889	883	890	912	934
Graduate	805	768	832	835	896
Education (Spouse)					
Illiterate	887	957	930	935	951
Primary	935	885	894	920	921
Secondary	817	801	877	904	901
Graduate	809	778	917	822	853

Table 4 Adjusted odds ratios and 95% confidence interval for being a male child for different independent household variables from a pooled analysis

	OR	95%	CI	*p*
Income Quartiles				
Poorest (Reference)	1			
2nd Poorest	1.02	1.00	1.03	0.04
2nd Richest	1.04	1.03	1.06	0.00
Richest	1.07	1.05	1.09	0.00
Education (Head)				
Illiterate (Reference)	1			
Primary	1.00	0.99	1.02	0.58
Secondary	1.01	0.99	1.03	0.38
Graduate	1.05	1.01	1.09	0.01
Education (Spouse)				
Illiterate (Reference)	1			
Primary	1.02	1.00	1.03	0.09
Secondary	1.02	1.00	1.05	0.04
Graduate	1.02	0.97	1.07	0.47
Caste				
Other Caste (Reference)	1			
Scheduled Tribe	0.98	0.96	1.01	0.17
Scheduled Caste	1.00	0.98	1.01	0.68
Religion				
Hindu (Reference)	1			
Muslim	0.99	0.97	1.01	0.25
Christian	0.97	0.94	1.00	0.08
Sikhs	1.00	0.97	1.04	0.97
Place of residence				
Rural (Reference)	1			
Urban	1.01	1.00	1.02	0.18
Survey Year				
1983 (Reference)	1			
1987-88	1.01	0.99	1.03	0.42
1993-94	1.01	0.99	1.03	0.33
1999-00	1.00	0.98	1.02	0.70
2004-05	1.00	0.98	1.02	0.73
State of residence				
Kerala (Reference)	1			
Andhra Pradesh	1.04	1.00	1.09	0.08
Assam	1.08	1.03	1.13	0.00
Bihar	1.05	1.01	1.10	0.02
Gujarat	1.09	1.04	1.14	0.00
Haryana	1.14	1.08	1.21	0.00
Himachal Pradesh	1.02	0.96	1.08	0.46
Karnataka	1.01	0.97	1.06	0.57
Madhya Pradesh	1.03	0.99	1.08	0.12
Maharashtra	1.05	1.01	1.10	0.02
Orissa	1.06	1.01	1.11	0.03
Punjab	1.18	1.12	1.25	0.00
Rajasthan	1.05	1.01	1.10	0.03

Tamil Nadu	1.04	1.00	1.09	0.06
Uttar Pradesh	1.07	1.02	1.11	0.00
West Bengal	1.02	0.97	1.06	0.46
Delhi	1.07	0.99	1.16	0.09
Other States	1.07	1.02	1.11	0.00

Figure 1 Child female:male ratio across five different time periods in India

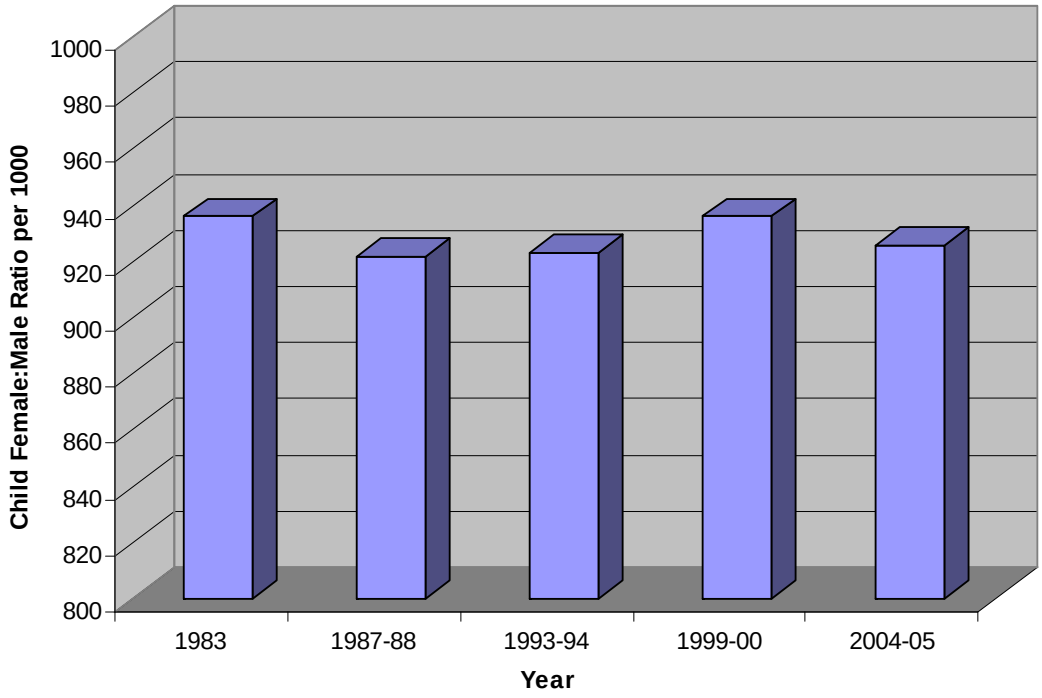
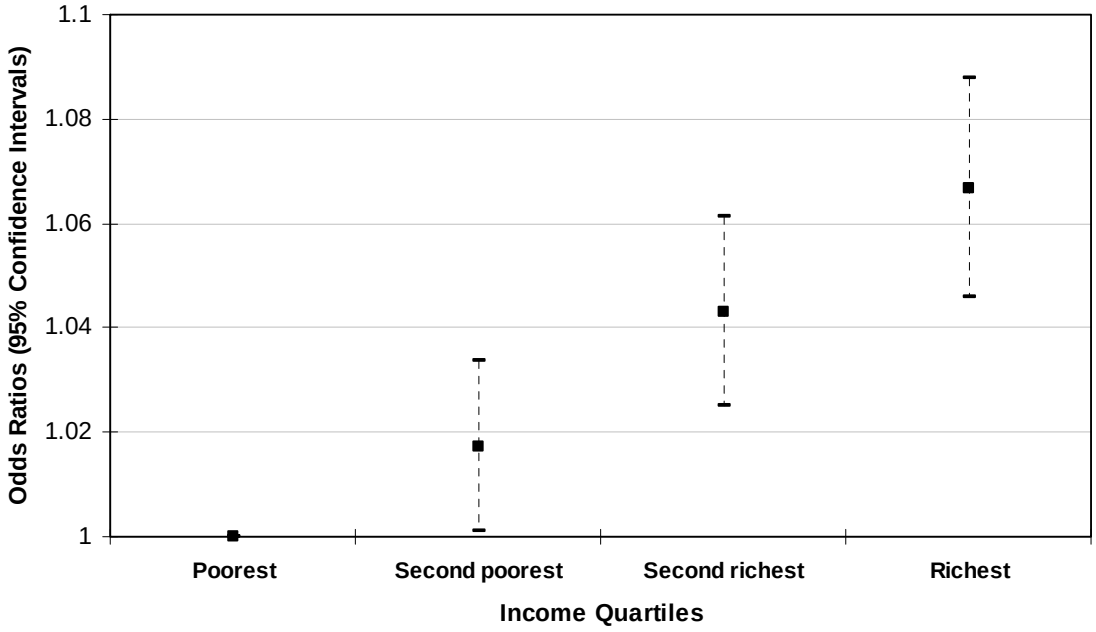
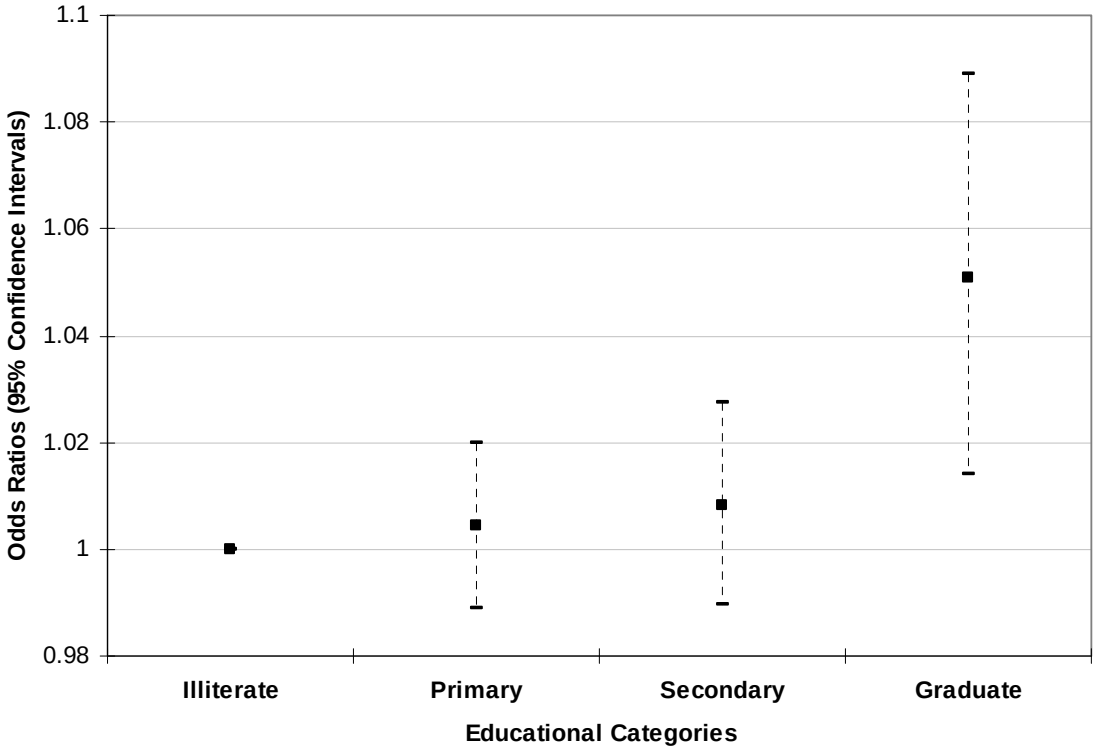


Figure 2 Adjusted odds ratios and 95% confidence interval for being a male child by (a) income quartiles; and (b) educational categories.

(a)

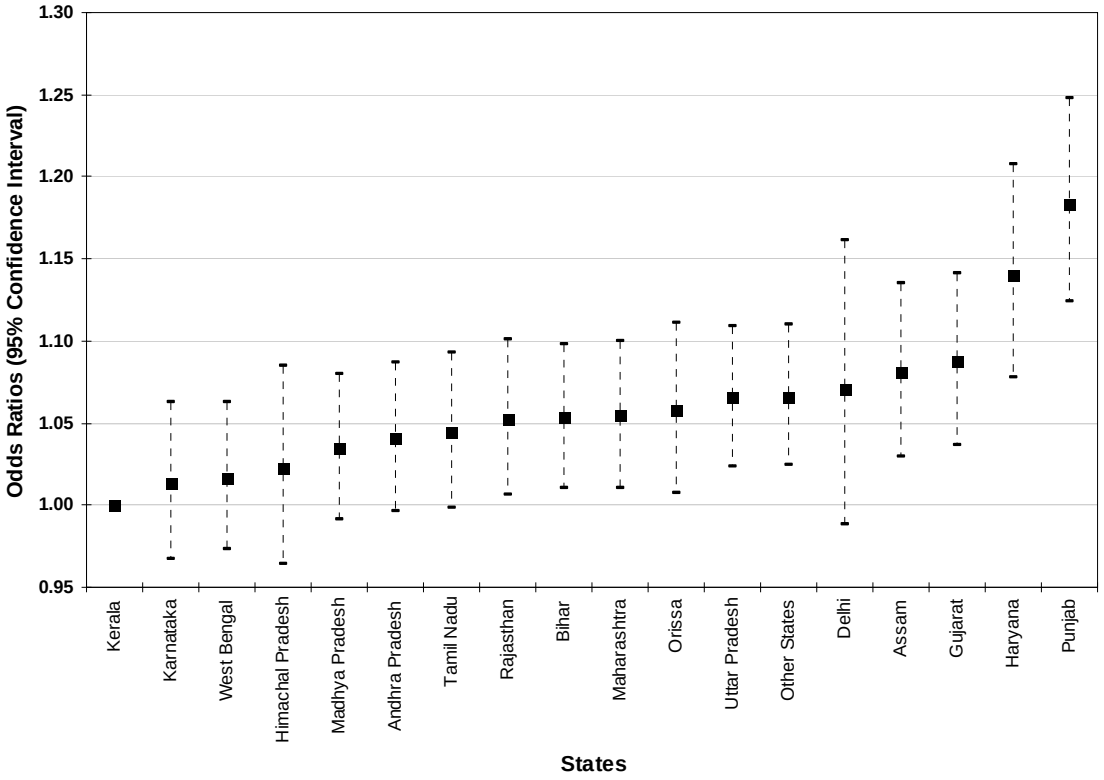


(b)



Note: Besides mutual adjustment, also adjusted for caste, religion, spouse's education, urban/rural status, time fixed-effects, and state fixed effects.

Figure 3 Adjusted odds ratios and 95% confidence interval for being a male child for different Indian states



Note: Adjusted for caste, religion, income quartiles, education of the head of the household, spouse's education, urban/rural status, and time fixed-effects.