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FERTILITY TRANSITION AND ADVERSE CHILD SEX RATIO IN DISTRICTS OF INDIA

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Summary. Demographic research in India over the last two decades has focused extensively on fertility change and gender bias at the micro-level, and less has been done at the district level. Using data from the Census of India 1991–2011 and other sources, this paper shows the broad pattern of fertility transition and trends in the child sex ratio in India, and examines the determinants of the child sex ratio at the district level. During 1991–2011, while the Total Fertility Rate (TFR) declined by 1.2 children per woman, the child sex ratio fell by 30 points in the districts of India. However, the reduction in fertility was slower in the high-fertility compared with the low-fertility districts. The gender differential in under-five mortality increased in many districts of India over the study period. The decline in the child sex ratio was higher in the transitional compared with the low-fertility districts. The transitional districts are at higher risk of a low child sex ratio due to an increased gender differential in mortality and increase in the practice of sex-selective abortions. The sex ratio at birth and gender differential in mortality explains one-third of the variation, while region alone explains a quarter of the variation in the child sex ratio in the districts of India.

Introduction

Over the last two decades, fertility transition and a decline in the child sex ratio (number of girls per 1000 boys in the 0–6 year age group) are concomitant in all the states of India. Fertility transition in India began in the early 1970s, intensified in the 1990s and is now taking place across all socioeconomic groups. The Total fertility Rate (TFR) in the country has declined by 34% over the last two decades, from 3.8 in 1990 to 2.5 in 2011, and the recent decline in fertility is largely contributed by poor and uneducated women (Bhat, 2002b; McNay *et al.*, 2003; Arokiasamy, 2009; Mohanty & Ram, 2011). Despite this progress, it is uncertain when India will achieve replacement level of fertility. The population stabilization in India is now contingent on the future fertility scenario in the states of Bihar and Uttar Pradesh, which have shown little reduction in their fertility levels (Das & Mohanty, 2012). On the other hand, the fertility decline over the last two decades has intensified gender discrimination before birth, leading to a sharp decline in

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the child sex ratio. The child sex ratio in India has deepened over time: from 962 in 1981 to 945 in 1991, 927 in 2001 and 914 by 2011 (Office of the Registrar General, 2012). The reduction in the child sex ratio has been found to be spread over all regions of the country (Kuzhiparambil & Rajani, 2012).

Conventionally, the child sex ratio is measured as the number of girls per 1000 boys, and the sex ratio at birth is measured as the number of male births per 100 female births. Here, the definitions are retained for the benefit of reader. The child sex ratio is directly affected by three factors: gender differentials in under-five mortality, gender differentials in under-enumeration and increased sex ratio at birth (number of male births per 100 female births). Although under-five mortality in India has declined over the last two decades, it has been unfavourable to females. For example, the under-five mortality among females in 2010 was 64 per 1000 live births compared with 55 per 1000 live births among males (RGI, 2012). Also, the data quality in the Indian census has improved over time and there is now no significant gender differential in under-enumeration for children under 10 years of age. In 2011, 260 districts with low sex ratio were given special attention to improve census coverage and data quality (RGI, 2011a). While the imbalance in the child sex ratio until the 1990s was largely attributed to excess under-five mortality and the undercounting of females, in recent years demographers have attributed it to parity, intensification and technological effects (Das Gupta, 1987; Das Gupta & Bhat, 1997; Das Gupta & Shuzhuo, 1999). Studies have established that sex-selective abortion is more common among socially and economically better-off groups and in more developed regions of India, leading to a skewed child sex ratio (Arnold *et al.*, 2002; Jha *et al.*, 2006, 2011; Arnold & Parasuraman, 2009; Roy & Chattopodhyay, 2012).

Despite the non-availability of birth statistics, complexity in deriving indirect estimates, lack of data on various socioeconomic indicators and increase in number of districts, there have been some notable attempts to study the variations and change in fertility in the districts of India. The first systematic attempt was made by the Registrar General of India (RGI) who published indirect estimates of fertility from the 1981 Census for all districts of India (RGI, 1989a). These estimates were subsequently revised and updated (RGI, 1989b, 1997). Dreze & Murthi (2001) used these fertility estimates and other socioeconomic variables to examine the determinants of fertility change in the districts of India. Bhat (1996) used data for the 0–6 year age group from the 1981 and 1991 Censuses to estimate the crude birth rate and TFR for 362 districts of India. He found large variations in the pace of fertility decline in different districts and a slow fertility decline in the districts with high fertility (TFR between 5 and 6). While the variables joint family, proportion of Muslim population, proportion of scheduled tribes, child mortality and unmet need for contraception were found to be positively related to fertility, female literacy, media exposure and population density tended to be negatively related to fertility. Guilmoto & Rajan (2001) examined the spatial pattern of the fertility transition over a period of 40 years (1951–91) in the districts of India based on the child–woman index and concluded that fertility decline was independent of other factors. Subsequently, they estimated TFR using data from the 0–6 year age group from the 2001 Census for all the districts of India (Guilmoto & Rajan, 2002). Ram *et al.* (2005) estimated the TFR for selected district of India using birth order statistics from the District Level Household Survey of 2002–04. Kumar & Sathyanarayana

(2012) estimated the CBR for 2001 and 2011 for the districts of India. Das & Mohanty (2012), using data for the 0–6 year age group in the 2011 Census, estimated the fertility level in the districts of two high-fertility states (Uttar Pradesh and Bihar) and found stalling fertility in most of the districts of Bihar and small changes in the districts of Uttar Pradesh.

Prior to publication of the provisional results of the 2001 Census, most research on fertility change and gender bias in India was in the context of son preference, gender discrimination and excess gender differentials in childhood mortality (Das Gupta, 1987; Murthi *et al.*, 1995; Das Gupta & Bhat, 1997; Dreze & Murthi, 2001). Das Gupta & Bhat (1997) outlined two opposing effects of fertility decline on gender bias: namely, the parity effect and intensification effect. When fertility declines, the parity effect decreases because of fewer births at higher parity, whereas the intensification effect becomes larger. The intensification effect becomes more pronounced at lower levels of fertility in the form of unreported female infanticide or sex-selective abortion. Accessibility to sonography (also labelled as a technological effect) outweighs the parity effect. After publication of age 0–6 data in the 2001 Census, researchers attributed the decline in the child sex ratio to the increasing practice of sex-selective abortion and excess child mortality (Jha *et al.*, 2006, 2011; Navaneethan & Dharamlingam, 2011; Kulkarni, 2012).

Technological developments and the increased gender imbalance over the last two decades warrants the investigation of fertility decline and the deepening child sex ratio in India, both at micro- and macro-levels. While micro-level studies have documented the increasing sex ratio at birth among socioeconomic groups leading to a skewed sex ratio, there has been no attempt to understand the link between fertility reduction and the declining child sex ratio at the district level in India. The aim of the paper was to (i) depict the pattern of fertility transition and decline in child sex ratio in the districts of India, and (ii) examine the determinants of the child sex ratio using a multivariate framework.

The paper has been conceptualized with the following rationale. First, both fertility reduction and the decline in child sex ratio are concomitant in Indian districts and the outcome of ‘diffusion’ processes. While fertility decline results from the diffusion of contraception, the diffusion of amniocentesis and ultrasonography technology allows sex detection and an increase in sex-selective abortion. Elimination of female fetuses is leading to an increasing sex ratio at birth and decline in child sex ratio (Dreze & Murthi, 2001; Bhat, 2002a; Guilmoto, 2008, 2009; Kuzhiparambil & Rajani, 2012). Second, there is considerable variation in the fertility level and gender bias within and across the districts of India. The number of districts (640 as per the 2011 Census of India) is quite large and heterogeneous in level of socioeconomic development, and provide an opportunity to explore the links between fertility reduction and gender bias at the sub-national level. The notion that sex-selective abortion is limited to developed regions of India is not true. Third, the district-level analysis can help to capture the social dimension of fertility change and gender bias (the social norm and diffusion effect), whereas household analysis misses the influence of other women on women’s fertility behaviour and sex preference (Dreze & Murthi 2001). Also, the district as the administrative unit has been key to many development programmes in India.

Data and Methods

Data were obtained from multiple sources: the Census of India 1991, 2001 and 2011, the Sample Registration System (SRS) annual reports, the Annual Health Survey (AHS 2011), the National Sample Surveys (NSS 2004–05 and 2009–10) and the District Level Household Surveys (DLHS 2002–04, 2007–08). The district is the unit of analysis, and available estimates were compiled/derived at the district level from various sources and a master data file prepared. The Child Sex Ratio (CSR) was the dependent variable. The level and decline in CSR was linked to a set of socioeconomic and demographic variables. The population in the 0–6 year age group for the 1991, 2001 and 2011 Censuses was used to estimate the Crude Birth Rate (CBR). The Total Fertility Rate (TFR) was derived from the estimated CBR. Information on literacy rate, urbanization, caste composition and under-five mortality was compiled from the Census of India publications. The state-level estimates of TFR, CBR and the abridged life-tables from the Sample Registration System were also used. The estimated under-five mortality rates for 1991 and 2001 for each district were used from the Census of India publication (RGI, 1997, 2009c). For 2011, the under-five mortality rate for 274 districts was taken from the estimates of the Annual Health Survey 2011 (RGI, 2011b). For the remaining districts it was assumed that the declines in mortality in 2001 and 2011 were similar to that observed at the state level. Similar assumptions were made by Bhat *et al.* (1997) in arriving at the fertility estimates for 1981 and 1991. However, the gender differential in mortality (ratio of female to male under-five mortality rate) for 2001 was used for 2011 in other analyses. The Sex Ratio at Birth (SRB) and other reproductive and child health indicators were computed from the unit data of the District Level Household Survey (DLHS). It has been found that, with the exception of a few districts, the SRB was in the acceptable range. The SRBs for the district of Balanagir in Odisha, West Kameng in Arunachal Pradesh, Mandya and Hassan in Karnataka, Khammam in Andhra Pradesh and South Garo Hills in Meghalaya in 2002–04 have been kept at their respective state averages. Similarly, the SRBs of Kathua and Kupwara districts in Jammu & Kashmir, West Garo Hills in Meghalaya, Dibang Valley and Lower Dibang Valley in Arunachal Pradesh, Kodarma and Purbi Singhbhumi in Jharkhand and Pudukkothai in Tamil Nadu have been kept at their respective state averages. The monthly *per capita* consumption expenditure (MPCE) was computed from the National Sample Survey, 2004–05 and 2009–10, for each district. The MPCEs of Poonch, Kargil and Leh districts in Jammu & Kashmir have been kept at their respective state averages, while for Mumbai districts the MPCEs were kept as that of Greater Bombay as the MPCEs were not available for these districts.

Note that the number of districts in India increased from 466 in 1991 to 593 in 2001, and to 640 in 2011. The estimates for the new districts were kept the same as those of the parent district from which it was carved out. The sample consisted of 618 districts in 1991, and 640 districts each in 2001 and 2011. The estimates were not available in the districts of Jammu and Kashmir for 1991 as the census was not conducted in this state in that year. Similarly, the DLHS-3 was not carried out in Nagaland and so these districts were not used in the analyses. The variables used, the data source, base year, final year, base year values and final year values are shown in Table 1.

The methods used in this paper are broadly of two types: estimates of CBR using the reverse survival method (RSM) and multivariate analyses (multiple regression and panel data regression). The RSM is a widely used indirect method of providing estimates of birth rate at the district level in India (Bhat, 1996; Guilmoto & Rajan, 2002; Das & Mohanty, 2012). The advantages of using the RSM and the use of the 0–6 year population to estimate the CBR have been discussed elsewhere (Bhat, 1996). The basic inputs used for RSM were population in the 0–6 age group, the mid-year population and the survival ratio. The population in the 0–6 age group was obtained from the census and those of mid-year population were computed using the inter-censal growth rate for each districts. To obtain the survival ratio of the 0–6 population, the under-five mortality and survival ratio were regressed at the state level for 2001 and 2008 using SRS data and it was found that the coefficient was stable over time. The survival ratio in the 0–6 age group (SR_{0-6}) was obtained from:

$$SR_{0-6} = 0.9969 - 0.0008 \times U5MR,$$

where U5MR is the under-five mortality, and the same was used at the district level.

The CBR with TFR were regressed at the state level for a period of 10 years (2000–2010) and the coefficients were used to arrive at the distinct-level estimates. While Bhat (1996) used a log-linear regression of TFR and CBR for seventeen states, we found that the regression without intercept fitted better. The estimated coefficient varied in the range of 0.10–0.14 with an R^2 value of 99. The estimated CBR and TFR derived by RSM refer to the mid-period of the census years (1988, 1998 and 2008) as the under 0–6 age group are survivors of births within 6 years of the census. Although indirect estimates of TFR for 1991 and 2001 were available from other sources, it was preferred to estimate the same to maintain the uniformity of the analyses.

A set of multiple regression equations (cross-sectional) and panel regression were used in the analyses. The fixed-effect model (within district) and random-effect (between districts) model on the pooled data were used to examine the district-specific effect on CSR. The covariates used were: gender differential in under-five mortality and sex ratio at birth, a set of developmental variables (female literacy, percentage urban, MPCE), programme variables (percentage of women sterilized with one or two sons only, percentage of institutional deliveries) and the region. The institutional delivery variable is conceived as a proxy for access to amniocentesis and ultrasound sonography as districts with higher institutional delivery coverage are likely to have higher access to these technologies to identify the sex of the baby. Similarly, districts with a higher proportion of women sterilized with one or two sons only are likely to practise the stopping rule and reduce the sex ratio of children. Region was kept as a domain to capture the socio-cultural aspect within the country.

The Indian districts were classified into seven regions: South, North, East, West, Central, North-East and undivided Uttar Pradesh (UP) and Bihar. The south region included the districts in the states of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Pudicherry, Lakshadweep and Andman and Nicobar; the East region included Odisha and West Bengal; the West region included Goa, Gujarat, Maharashtra, Dadra Nagar Haveli, Daman and Diu; the North region included Delhi, Haryana, Himachal

Pradesh, Jammu & Kashmir, Punjab, Chandigarh, Rajasthan; the Central region included Madhya Pradesh and Chhattisgarh; and the Districts of Uttar Pradesh and Bihar and the North-East states were placed in separate groups owing to their high fertility and low level of development.

In the first model, the CSR was regressed against a set of predictor variables to understand the role of each factor in explaining variation in CSR. In the second regression model, the CSR was first regressed against the explanatory variables for each time period and then a pooled regression were carried out. The fixed-effect model allows the relationship to be studied between changing condition and CSR, and the slope coefficient of the fixed-effect model explains the change in CSR holding the district-specific effect constant.

The panel regression equation used was in the form of:

$$\mathrm{CSR}_{dt} = \alpha_d + \beta X_{dt} + Y_t + e_{dt},$$

where CSR_{dt} is the child sex ratio in district d at time t; X_{dt} is the vector of explanatory variables; Y_t is a time dummy variable and e_{dt} is the error term. The estimated TFR, SRB and CSR values are presented using Arc Map 10.

The validity and reliability of the estimates were checked by comparing the district and state estimates with published sources. For 2001, the correlation coefficient of our estimates with those of Guilmoto & Rajan (2001) for the districts of India was 0.94. Similarly, for 1991, the correlation coefficient of our estimates with those of the RGI was 0.83. For 2006–11, at the national level, our estimated TFR was 2.5 compared with 2.6 in 2010. The state-level estimates varied in the range of 10% from the SRS indicating that our estimates were reliable. The state-level correlation coefficient of the estimated TFR and that from the SRS was 0.98 for 2008.

Results

Table 1 presents the data sources, base years and final year for which data were available and the mean and standard deviation of the variables used in the analyses. The mean district population size in India has increased from 1.32 million in 1991 to 1.89 million in 2011. The mean TFR declined from 3.87 in 1988 to 2.66 in 2008, while the child sex ratio declined by 30 points over the 20-year period 1991–2011. Though the under-five morality declined from 106 per 1000 live births in 1991 to 68 in 2011, the gender differentials in under-five mortality seemed to have widened. The social composition of the population with respect to caste groups remains similar in the districts of India. Female literacy, MPCE and urbanization have increased over time, indicating progress in social and economic development in the districts of India. Both the programme variables of institutional delivery and percentage of sterilized couples with one or two son has increased over time. The average sex ratio at birth in all districts of India was close to that of the SRS. During 1991–2011, the share of population in the districts belonging to the southern states declined from 23.3% to 20.9%, while that of undivided Uttar Pradesh and Bihar increased from 26.6% to 28.6%.

Table 1. Data sources and descriptive statistics of study variables in districts of India, 1991–2011

Variable	Source	Base year	Final year	Mean of base year	Mean of final year
Mean population size (million)	Census of India	1991	2011	1.32	1.89
Crude Birth Rate (CBR)	Indirect estimates using reverse survival method	1991	2011	32.03 (5.7)	22.06 (5.6)
Total Fertility Rate (TFR)	Derived from CBR	1991	2011	3.87 (0.93)	2.66 (0.84)
Sex ratio of children in 0–6 age group	Census of India	1991	2011	949 (34.2)	919 (43.4)
Under-five mortality rate	Census of India	1991	2011	106 (36.1)	68.03 (25.3)
Female literacy (%)	Census of India	1991	2011	37.8 (17.7)	63.5 (12.6)
Percentage urban	Census of India	1991	2011	22.4 (18.1)	26.3 (21.0)
Percentage scheduled caste population	Census of India 2001	1991	2001	14.9 (8.6)	14.39 (8.7)
Percentage schedule tribe population	Census of India 2001	1991	2001	16.53 (25.8)	16.92 (26.4)
Percentage Muslim population	Census of India 2001	1991	2001	9.88 (11.1)	12.38 (16.7)
Percentage girls marrying at <18 years	DLHS	2002–04	2007–08	28.32 (18.8)	22.13 (16.2)
Contraceptive use (%)	DLHS	2002–04	2007–08	43.9 (15.5)	48.17 (16.1)
Three or more antenatal care visits	DLHS	2002–04	2007–08	52.7 (26.4)	54.03 (26.1)
Percentage institutional deliveries	DLHS	2002–04	2007–08	42.2 (24.0)	50.41 (24.5)
Percentage children immunized	DLHS	2002–04	2007–08	47.5 (26.7)	57.2 (22.2)
Percentage married women sterilized		2002–04	2007–08	31.1 (15.2)	36.3 (16.5)
Percentage population living below poverty line	NSSO, 61(1)[b] & 66(1)[c]	2004	2010	37.57 (20.5)	29.8 (19.9)
Mean MPCE at 2004–05 prices	NSSO, 61(1)[b] & 66(1)[c]	2004	2010	709.3 (267.8)	890.5 (357.7)
Share of population in regions	Census of India	1991	2011	1991	2011
South				23.34	20.91
East				11.79	11.01
West				14.37	14.44
North excluding UP				12.27	13.13
Central (undivided MP)				7.82	8.11
Undivided Bihar and UP				26.64	28.63
North-eastern states				3.78	3.77
Total number of districts	Census of India	618[a]	640	NA	NA

[a] Census 1991 was not held in Jammu & Kashmir. NA: not applicable.
[b] National Sample Survey Organisation, 61st round (Type 1 schedule).
[c] National Sample Survey Organisation, 66th round (Type 1 schedule).
Figures in parentheses are standard deviations.

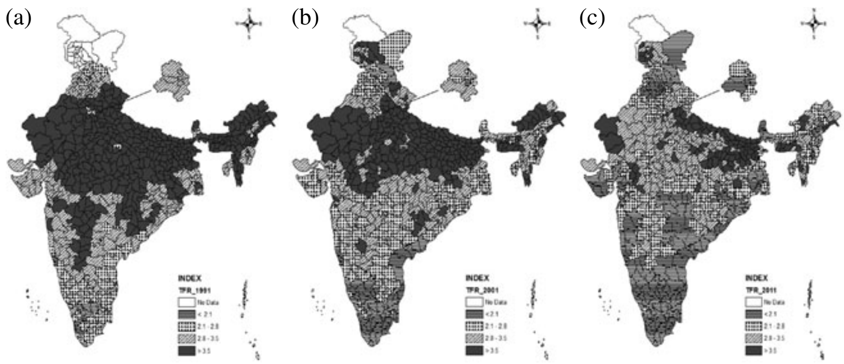

Fig. 1. Estimated TFR in districts of India, 1985–91 (a), 1995–2001 (b) and 2005–11 (c).

Fertility transition and child sex ratio in districts of India

Figure 1 presents the estimated TFR for the periods 1985–91, 1995–01 and 2005–11, derived from the 0–6 population of the 1991, 2001 and 2011 censuses. For convenience these estimates refer to their mid-periods, i.e. 1988, 1998 and 2008, respectively. The results indicate large inter-district variation in the estimated TFR for all three time periods. The estimated TFR varied from a high of 5.0 in the district of Khagaria (Bihar) to 1.1 in the district of Kolkata (West Bengal) in 2008. There were 22 districts from the states of Kerala, Andhra Pradesh, Karnataka, Goa, Tamil Nadu, Himachal Pradesh and Maharashtra with TFRs of less than 1.5 indicating the lowest fertility in these districts. In 1988, the TFR (5.7) was highest in the districts of Garhwa, Latehar and Palamu (Jharkhand State) followed by Jhabua (5.6, Madhya Pradesh) and the lowest (1.6) was in Kolkata (West Bengal). The coefficient of variation in TFR for all districts increased from 0.24 in 1988 to 0.31 by 2008 indicating increasing inter-district variation. Among the major states of India, the coefficient of variation of TFR in 1991 was maximum (0.18) in the state of West Bengal and minimum in the state of Bihar (0.04). By 2011, the coefficient of variation in TFR was maximum in the state of Haryana (0.20) and minimum in the state of Punjab (0.06) followed by Bihar (0.09). A significant reduction in TFR was also observed in almost all the districts of India (barring five districts) indicating that the fertility transition is underway but at varying degrees. To understand the pattern of fertility transition, Bhat (1996) linked the level of TFR in the districts of India to their variance: low variance and normal curve in the early stage (Stage I), increased variance and negative skewed during the transitional period (Stage II), large variance and normal curve (Stage III), declining variance and positively skewed thereafter (Stage IV) and a small variance and a normal curve at the time of completion of transition (Stage V). The variance of TFR in districts of India increased from 0.87 in 1988 to 0.91 in 2001 and declined to 0.71 by 2011. The distribution of TFR was negatively skewed over time, confirming the fertility transition in districts of India. However, the pattern varies largely in states of India. In the case of the high-fertility state of Uttar Pradesh, the variance in TFR increased from 0.10 in 1991 to 0.14 in 2001 and 0.17 in 2011, indicating that the state is in the second stage of demographic

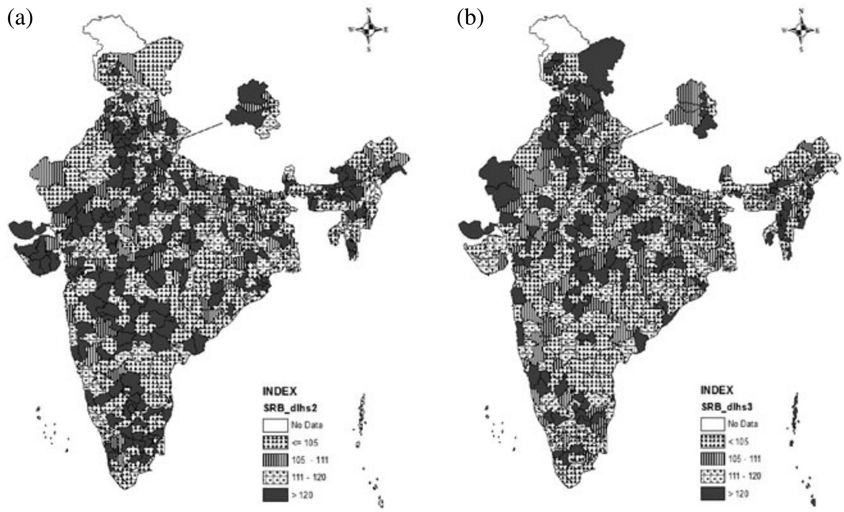

Fig. 2. Estimated sex ratio at birth in districts of India, 2002–04 (a) and 2007–08 (b).

transition. In the case of Bihar, the variance in TFR increased from 0.05 in 1991 to 0.09 in 2001 and 0.15 in 2011. In the case of Maharashtra, the variance in TFR declined from a high level of 0.24 in 1991 to 0.11 in 2011, indicating the transition in districts of Maharashtra. On the other hand, the variance of TFR in Tamil Nadu (a low-fertility state) declined from 0.068 in 1991 to 0.025 in 2001 and 0.018 by 2011. The distribution of TFR indicates the varying stage of fertility transition in the districts of India. The high fertility in Indian districts (TFR of more than 3.5) in 2011 was confined to just a few states: Bihar, Uttar Pradesh, Jharkhand and Madhya Pradesh.

The child sex ratio was also analysed in the districts of India for 1991–2011. Like TFR, the CSR varies largely among the districts of India over all the period. It has declined in many districts and worsened over time. In 1991, the CSR varied from 1036 in the district of East Kameng (Arunachal Pradesh) to 849 in the districts of Salem and Namakkal (Tamil Nadu). By 2011, the lowest CSR was observed in the Jhajjar district of Haryana (774) and the highest in Lahul and Spiti (1013) in Himachal Pradesh. Many of the districts with CSRs of less than 850 were in the states of Uttar Pradesh, Haryana, Punjab, Maharashtra and Jammu & Kashmir. During 1991–2011, the maximum decline in CSR was observed in the districts of Salem (68 points) followed by Namakkal (64) in Tamil Nadu. Earlier studies also reported high female feticide and infanticide in the Salem district of Tamil Nadu (George, 1997). The variance in CSR in the districts of India increased from 1171 in 1991 to 2368 in 2001 and declined to 1880 by 2011. On examining the state pattern in CSR it was found that while the variance in CSR remained similar in that in Kerala at a low level during 1991–2011, it increased from 94 in 1991 to 254 in 2001 and 328 in 2011 in the state of Punjab. Even in high-fertility states the variance in CSR remained higher than in the state of Punjab. Figure 2 presents the sex ratio at birth in the districts of India, one of the proximate determinants of the child sex ratio. An increase in sex ratio at birth was observed in

Table 2. Per cent distribution of districts by levels of CBR, TFR, CSR and other selected indicators in India, 1991–2011

	Percentage of districts			Percentage of population		
Variable	1991	2001	2011	1991	2001	2011
Level of TFR[a]						
≤2.1	2.59	10.94	32.34	3.50	13.46	38.11
2.1–2.8	11.49	26.72	25.63	16.15	31.15	22.55
2.81–3.5	25.08	22.03	24.22	27.38	17.64	21.56
>3.5	60.84	40.31	17.81	52.97	37.74	17.78
Level of CBR[a]						
≤18	0.33	4.38	28.44	2.16	5.06	32.64
18.1–22	0.99	19.69	23.59	6.26	24.54	23.12
22.1–28	12.97	31.25	33.13	24.15	29.44	31.63
>28	85.71	44.69	14.84	67.44	40.96	12.61
Child sex ratio						
≤877	3.72	13.59	18.13	2.59	13.14	19.42
877–913	11.65	10.94	19.69	11.53	12.81	20.25
914–950	27.02	30.78	34.69	32.10	33.98	38.29
>950	57.61	44.69	27.50	53.78	40.07	22.04
Under-five mortality rate						
<40	0.49	0.94	9.38	0.66	1.53	13.19
40–67	11.97	13.28	45.47	15.69	17.71	46.87
68–100	37.54	41.41	36.09	38.26	42.82	31.31
100+	50.0	44.38	9.06	45.39	37.95	8.63
Female literacy rate						
≤40	60.03	25.31	2.34	57.63	23.56	1.28
40.01–60	28.64	40.0	37.03	30.37	40.57	36.35
60.01–80	8.41	28.13	51.56	8.84	29.14	50.61
80+	2.91	6.56	9.06	3.16	6.73	11.75
Percentage urban						
≤15	38.35	40.16	35.0	33.10	33.09	29.13
15–33	44.01	37.66	39.22	43.64	37.84	36.17
33–50	10.36	12.34	13.44	12.58	13.91	15.77
50+	7.28	9.84	12.34	10.68	15.15	18.92
Number of districts	618	640	640	618	640	640
Total percentage	100	100	100	100	100	100

[a] Estimates of TFR and CBR refer to the periods 1988, 1998 and 2008.

almost every state of India during 2002–04 and 2007–08, indicating a possible increase in sex-selective abortion in every part of the country.

Table 2 presents the percentage distribution of Indian districts and their population share by levels of CBR, TFR, child sex ratio, under-five mortality, female literacy and urbanization. The distribution of CBR and TFR indicates a fast reduction in the fertility level in all districts. The number of districts with below replacement level fertility increased from sixteen in 1991 to 207 by 2011, while the number of districts with a TFR

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of more than 3.5 declined from 376 to 114 over the same time period. The share of population in districts with below replacement level fertility increased from 3.5% in 1991 to 38% by 2011. On the other hand, districts with high fertility (TFR > 3.5) still accounted for 17.8% of India's population in 2011. The high-fertility districts were mostly in the states of Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan, Chhattisgarh and Jammu & Kashmir, which have low contraceptive prevalence. The trend in child sex ratio was similar to that of TFR. The number of districts with a child sex ratio of less than 877 increased from 23 in 1991 to 116 by 2011, while the number with more than 950 declined from 356 to 176 over the same period. Both mortality and female literacy have improved over time. The distribution of the under-five mortality rate showed a significant change by district: the percentage of districts with an under-five mortality rate of 100 or more declined from about 50% in 1991 to less than 10% by 2011. In 2011 there were few districts where the level of female literacy was less than 40% and the variance in female literacy has declined over time. Similarly, the percentage of districts with an urban population of more than 50% increased from 7.28% in 1991 to 12.34% by 2011.

Table 3 presents the decline in CSR by current level of TFR and absolute change in TFR by district. Of districts with below replacement level of fertility in 2011, 16% experienced no decline, 42% experienced a 1–25 point decline, 27% experienced a 26–50 point decline and 15% experienced a more than 50 point decline in CSR during 1991–2011. On the other hand, among districts with high fertility (TFR > 3.5), 16% of districts did not experience any decline, 45% experienced a 1–25 point decline, 30% experienced a 26–50 point decline and 9% experienced a more than 50 point decline in the child sex ratio. The reduction in CSR was higher in the transitional districts (TFR between 2.1 and 3.5). Of the 161 districts that had a TFR in the range of 2.1–2.8, about two-thirds experienced a reduction in CSR of more than 25 points. The decline in CSR was equally high during 1991–2001 and 2001–11. On linking the change in CSR and TFR (absolute) in the districts of India (lower panel of Table 3), it was found that of the 174 districts with a decline in TFR of more than 1.5 during 1991–2011, 5.2% recorded no decline, 47.1% recorded a 1–25 point decline, 28.7% recorded a 26–50 point decline and 19% recorded a more than 50 point decline in CSR. On the other hand, of the 150 districts with a decline in TFR in a small range (between 0.5 and 1) in last two decades, 22.6% of districts had no decline, 43% had a 1–25 point decline, 25% had a 26–50 point decline and 8.7% had a more than 50% decline in CSR.

Table 4 presents the pace of fertility reduction and decline in CSR in Indian districts by the level of CSR and TFR class in 1991. The results indicate that districts in the high-TFR class (TFR of more than 5) showed a 27% reduction in TFR compared with 35% among districts with a TFR of 3–4, and 32% among districts with a TFR of less than 3. On the other hand, the reduction in CSR was visible in all districts and, in fact, more so in districts with a better CSR. The average decline in CSR was 20 points among districts with a CSR of less than 878, 31 points among districts that had a CSR in the range of 878–913, 30 points among those with a CSR in the range of 914–950 and 28 points in those with a CSR of more than 950.

Table 3. Percentage distribution of districts by decline in child sex ratio, current level of TFR and absolute change in TFR in India, 1991–2011

	Level of TFR in 2011				
Decline in CSR	≤2.1	2.1–2.8	2.9–3.5	3.5+	All
1991–2011					
No decline or increase	16.10	4.97	4.83	15.89	10.52
1–25 point	41.95	35.40	42.07	44.86	40.78
26–50 point	26.83	30.43	37.93	29.91	30.91
>50 point	15.12	29.19	15.17	9.35	17.80
Total districts	205	161	145	107	618
2001–11					
No decline or increase	42.51	29.27	10.32	27.19	28.59
1–25 point	46.38	46.34	56.13	38.60	47.34
26–50 point	7.25	17.68	26.45	26.32	17.97
>50 point	3.86	6.71	7.10	7.89	6.09
Total districts	207	164	155	114	640
1991–2001					
No decline or increase	19.02	9.94	25.52	27.10	19.58
1–25 point	50.73	45.96	55.86	56.07	51.62
26–50 point	12.20	29.19	17.24	15.89	18.45
>50 point	18.05	14.91	1.38	0.93	10.36
Total districts	205	161	145	107	618
	Absolute change in TFR during 1991–2011				
	>1.5	1–1.5	0.5–1	<0.5	
1991–2011					
No decline or increase	5.17	5.28	22.67	27.59	10.52
1–25 point	47.13	35.09	43.33	41.38	40.78
26–50 point	28.74	36.98	25.33	17.24	30.91
>50 point	18.97	22.64	8.67	13.79	17.80
Total number of districts	**174**	**265**	**150**	**29**	**618**

Association of child sex ratio, sex ratio at birth and gender differential in mortality with other variables

To understand the association of CSR with its determinants, a correlation matrix was computed for each time period. The correlation coefficient of CSR with SRB was stable: −0.24 in 2011 and −0.22 in 2001. The correlation coefficient of CSR and gender differential in mortality was −0.3 in 1991, −0.48 in 2001 and −0.50 by 2011. The association of CSR and TFR though positive was small (varying in the range of 0.001–0.01) throughout the period. The correlation coefficient of CSR and percentage urbanization were −0.24 each in 1991 and 2001 and −0.17 in 2011. All these suggest that the association of CSR with developmental variables changed over time.

Table 4. Average declines in child sex ratio and TFR during 1991–2011 in districts of India

	Number of districts in 1991	Unweighted average of CSR and TFR			Absolute decline	Percentage decline
		1991	2001	2011		
CSR in 1991						
<878	24	864	809	844	20	2.3
878–913	71	893	859	862	31	3.5
914–950	167	934	918	904	30	3.2
>950	356	972	958	944	28	2.9
All[a]	618	948	930	920	28	3.0
TFR class in 1984–90						
5+	71	5.2	4.6	3.8	1.4	26.9
4–5	227	4.5	4	3.2	1.3	28.9
3–4	197	3.4	2.8	2.2	1.2	35.3
≤3	123	2.5	2.1	1.7	0.8	32.0
All[a]	618	3.9	3.3	2.7	1.2	30.8

[a] Excludes the districts of Jammu & Kashmir.
Fertility estimates refer to 6-year average prior to census year.

Determinants of the child sex ratio in the districts of India

To understand the determinants of CSR, a set of regression models were run. In the first set, the CSR was regressed with its determinants for 2011 and 2001. The selection of independent variables was guided by the literature and the availability of data to measure the variable. Table 5 shows the results of four different models to understand the variation in CSR in 2011 (columns 2–5). In Model 1, two proximate determinants of CSR were used, namely sex ratio at birth and gender differentials in mortality. These two variables, along with gender differentials in enumeration, are often given as causes of declining CSR. It was observed that both these variables explained 29% of variation in CSR and was significant in the model. In Model 2, the developmental and demographic variables were introduced: percentage urban, female literacy, MPCE, TFR along with the variables in Model 1. An interaction term of female literacy and percentage urban population was also included. The inclusion of these four variables increased the predictive ability of the model from 29% to 38%. All these variables were statistically significant. In Model 3, programme variables were introduced to understand whether the percentage of mothers sterilized with one or two child and percentage of institutional deliveries affects the CSR. Institutional delivery is used as a proxy for access to ultrasound sonography. On the other hand, stopping behaviour (sterilization with one or two sons) might have resulted in a decline in CSR. Both these variables increased the R^2 value by 1% only. In Model 4, the regional dummies were included, along with all the variables in Model 3. The inclusion of region as an explanatory variable increases the R^2 value by 25% indicating that region is a significant

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Table 5. Results of Ordinary Least Squares (OLS) analysis on factors affecting child sex ratio in districts of India, 2001–2011

	2011				2001
	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	1172*** (72.83)	1240*** (58.04)	1234*** (55.28)	1203*** (63.64)	1136*** (54.09)
Sex ratio at birth	−0.471 (5.8)	−0.360*** (4.72)	−0.355*** (4.65)	−0.274*** (4.61)	−0.133 (1.42)
Gender differential in mortality	−0.166*** (14.3)	−0.153*** (12.99)	−0.158*** (13.31)	−0.119*** (11.24)	−0.147*** (11.87)
Developmental variables					
TFR		−3.44 (1.55)	−0.834 (0.28)	2.47 (0.95)	14.91*** (5.57)
Female literacy		−0.814*** (3.81)	−0.868*** (4.05)	−0.894*** (4.82)	−0.139 (1.09)
Percentage urban		−3.64*** (7.61)	−3.597*** (7.57)	−2.90*** (7.79)	−0.914** (3.42)
MPCE		−0.037*** (6.57)	−0.038*** (6.80)	−0.007 (1.50)	−0.002 (0.23)
Programme variables					
Percentage women sterilized with 1 or 2 sons			−0.707 (1.40)	−0.177 (0.40)	−1.068* (1.74)
Percentage institutional deliveries			0.30** (3.25)	−0.157* (1.77)	0.022 (0.38)
Regional dummies					
South (Ref.)					
East				−33.74*** (6.00)	−28.87*** (4.39)
West				−53.11 (11.38)	−44.65*** (8.13)
North excluding UP				−78.999*** (16.60)	−84.89*** (14.34)
Central (undivided MP)				−38.42*** (6.88)	−44.71** (6.59)
Undivided Bihar and UP				−44.02*** (6.78)	−52.33*** (6.95)
North-East states				−17.41** (2.74)	−25.48** (3.46)
Interaction (urbanization × female literacy)	–	0.051*** (8.1)	0.049*** (7.85)	0.0392*** (7.98)	0.011** (2.87)
F	127.71	56.67	45.91	75.51	47.84
Adjusted R^2	28.78	38.33	39.20	64.06	52.45
N	628	628	628	628	638

Figures in parentheses are t-statistics.
$*p < 0.001$; $**p < 0.05$; $***p < 0.10$.
2001 level of gender differential in mortality kept for 2011.

predictor of skewed sex ratio in India. It was observed that all regions had experienced a significant decline in CSR compared with the southern region. To understand the nature of the relationship over time the explanatory variables for 2001 were used as well (Model 5). The gender differential in mortality, percentage urban, TFR, percentage of women sterilized with one or two son and region were statistically significant in 2001. The sex ratio at birth was not significant in 2001 but significant in 2011, while the level of TFR was significant in 2001 but not in 2011. The predictive ability of the model (R^2) increased during 2001 and 2011 by including the set of additional variables.

The CSR was also regressed against the predictor for 1991, 2001 and 2011 by pooling the data for 1991–2011. In the pooled data the fixed-effect and random-effect models were estimated to understand the district-specific effect (Table 6). The models were run on the panel data for 1991–2011 and 2001–11. The fixed-effect models for 1991–2011 and 2001–11 were also used because more variables were available in 2001 and 2011. In the random-effect model of 1991–2011, the gender differential in mortality, TFR, female literacy, percentage urban and region were statistically significant. In the fixed-effect model the gender differential in mortality, TFR, female literacy, region and time were significant predictors. This indicates that the cross-sectional results also hold true in the fixed-effect model. On adding more variables and estimating the random effect model for 2001–11 it was found that sex ratio at birth, gender differential in under-five mortality, female literacy, TFR, percentage urban, region and time were significant predictors of CSR. When the district effect was fixed, TFR, percentage urban, MPCE, percentage of women sterilized with one or two son and time were significant in the model. The gender differential in mortality was dropped because the level in 2001 was used for 2011. Of all the variables, the effect of region was large in all the models.

Discussion

The decline in the child sex ratio in India over the last two decades is a matter of grave concern for planners, policymakers and civil society. While several measures by national and state government and international organizations have helped to reduce infant and child mortality, it has been offset by an increase in sex-selective abortion. Amniocentesis and ultrasonography have been available in India from around the early 1980s to identify pregnancy complications and save the lives of mothers and children, but they have been misused for sex determination and the elimination of female fetuses. While the use of ultrasound is inevitable for the improvement of maternal and child health (Banerjee & Mohanty, 2012), the misuse of the technology is alarming. Despite concerted efforts by the central government, state governments and non-governmental organizations to prohibit sex determination tests and sex-selective abortion, these have spread from highly developed regions to poorly developed regions and are now prevalent all over the country. The decline in the child sex ratio is linked to fertility changes because of the inherent gender bias and son-preference across socioeconomic groups in India. Though the desire for a large family is disappearing in India, son preference persists and demographers have termed it the ‘parity intensification effect’. The pattern of increasing sex ratio at birth and reduction in fertility in India is similar to that in other Asian countries. While the fertility transition is irreversible, researchers are optimistic

Table 6. Result of Ordinary Least Squares (OLS) analysis on factors affecting child sex ratio in districts of India, 1991–2011: random- and fixed-effect models

	1991–2011		2001–11	
	Panel random effect	Fixed effect	Panel random effect	Fixed effect
Constant	1054*** (9.11)	982*** (79.29)	1132*** (15.05)	932*** (54.71)
Sex ratio at birth	–		−0.12** (0.047)	−0.013 (0.24)
Gender differential in mortality	−0.082*** (0.006)	−0.045*** (6.39)	−0.135*** (0.01)	
Developmental variables				
TFR	7.88*** (1.53)	4.52** (2.14)	8.83*** (1.98)	−7.56** (2.07)
Female literacy	−0.369*** (0.065)	−0.175** (2.33)	−0.26** (0.088)	−0.01 (0.09)
Percentage urban	−0.849*** (0.142)	−0.028 (0.16)	−0.93*** (0.202)	0.418 (1.48)
MPCE			−0.003 (0.004)	0.007 (1.07)
Programme variables				
Percentage women sterilized with 1 or 2 sons	–		−0.076 (0.339)	0.752* (1.90)
Percentage institutional deliveries	–		0.014 (0.033)	0.037 (1.01)
Year				
2001	2.78 (1.83)	−6.15** (2.74)		
2011	−2.46 (2.48)	−14.70*** (4.32)	−5.65** (1.74)	−21.53*** (7.22)
Regional dummies				
South (Ref.)				
East	−11.77** (4.28)		−24.22*** (5.07)	
West	−38.75*** (3.84)		−46.89*** (4.34)	
North excluding UP	−73.02*** (3.51)		−77.72*** (4.26)	
Central (undivided MP)	−26.63*** (4.33)		−34.53*** (5.02)	
Undivided Bihar and UP	−36.02*** (4.24)		−37.26*** (5.26)	
North-East states	−4.91 (3.97)		−12.24** (5.10)	
Interaction (% urban × female literacy)	0.011*** (0.002)	0.003 (1.45)	0.013*** (0.003)	0.004 (1.13)
Wald χ^2 (13)	1734		1142	
F		4.48		3.31
N	1898		1266	

Figures in parentheses are standard errors.
*$p < 0.001$; **$p < 0.05$; ***$p < 0.1$.

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about bringing normalcy to the sex ratio at birth. Guilmoto (2009) described the transition in the sex ratio at birth in China and South Korea as having two phases: an increase in the first phase and reversal to normalcy in the second phase. The transition of the SRB is said to have completed in South Korea, and was made possible by concerted public action.

Though fertility reduction and gender bias have been dealt with extensively in the demographic literature, there have been only a limited number of studies focusing on India at the district level. This is perhaps due to the non-availability of direct fertility estimates and developmental indicators and the complexity involved in district-level analyses in India. The compilation or derivation of district-specific indicators for three periods of time is a daunting task. In this study, data were compiled from various sources and there are methodological and data constraints in deriving these estimates. A concerted attempt was made to sort out these issues by making reasonable assumptions. The aim of this paper was to depict the broad pattern of fertility change and examine its linkage with the child sex ratio in the districts of India. Using a uniform methodology and data from three consecutive censuses (1991, 2001 and 2011), estimates of CBR and TFR were derived for all the districts in India. These estimates were compared with earlier estimates and found to be reliable. Along with the census estimates, programme indicators from the DLHS and estimates from the MPCE from NSS were included. While earlier studies used a limited number of variables, this study used a relatively large number of variables in the multivariate framework and covered almost all the districts in India.

In conclusion, this study has made the following findings. Indian districts with low fertility have recorded a decline in CSR but the reduction is larger in high-fertility districts. In fact, the transitional districts are experiencing excess female mortality and increased sex-selective abortion and are at higher risk of a deepening sex ratio in the future. The results confirm the findings of micro-level studies on the linkages of declining fertility and child sex ratio in India. Second, though the reproductive and child health programme has been successful in reducing under-five mortality, the gender differentials in under-five mortality seem to have widened during 1991–2011. Third, along with increased sex ratio at birth and the gender differential in mortality, region is central in explaining the variation in CSR in India. While one-third of the variation in the CSR can be explained by the sex ratio at birth and the gender differential in mortality, region explained about a quarter of the variation in CSR. Fourth, programme variables such as increased emphasis on sterilization are significant in explaining the variation in the child sex ratio within a district. Fifth, though the fertility transition is universal in Indian districts, the fertility reduction has been lowest in the districts with highest fertility.

Based on these findings it is suggested that there is a need to evolve a comprehensive strategy to reduce the gender differential in child mortality in India, and curb sex-selective abortion so as to improve the child sex ratio. Targeted interventions will help to reduce the fertility level in high-fertility districts and strict implementation of the existing law on sex-selective abortion throughout the country will be helpful to improve the child sex ratio.

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References

Arnold, F., Kishor, S. & Roy, T. K. (2002) Sex selective abortions in India. *Population and Development Review* **28**(4), 759–785.

Arnold, F. & Parasuraman, S. (2009) The effect of ultrasound testing during pregnancy on pregnancy termination and the sex ratio at birth in India. Paper presented at the *XXVI International Population Conference, IUSSP, Marrakech, Morocco*, 27th September–2nd October.

Arokiasamy, P. (2009) Fertility decline in India: contributions by uneducated women using contraception. *Economic and Political Weekly* **XLIV**(30), 55–64.

Banerjee, S. K. & Mohanty, S. K. (2012) Understanding the role of ultrasound (USG) in improving maternal care in India. *Ipas*, 10th January 2012.

Bhat, P. N. M. (1996) Contours of fertility decline in India. In Srinivasan, K. (ed.) *Population Policy and Reproductive Health*. Hindustan Publishing Corporation (India), New Delhi.

Bhat, P. N. M. (2002a) On the trail of missing Indian females II: Illusion and reality. *Economic and Political Weekly* **37**(52), 5244–5263.

Bhat, P. N. M. (2002b) Returning a favor: reciprocity between female education and fertility in India. *World Development* **30**(10), 1791–1803.

Das, M. & Mohanty, S. K. (2012) Spatial pattern of fertility transition in Uttar Pradesh and Bihar: a district level analysis. *Genus* **68**(2), 81–106.

Das Gupta, M. (1987) Selective discrimination against female children in rural Punjab, India. *Population and Development Review* **13**(1), 77–100.

Das Gupta, M. & Bhat, P. N. M. (1997) Fertility decline and increased manifestation of sex bias in India. *Population Studies* **51**(3), 307–315.

Das Gupta, M. & Shuzhuo, L. (1999) Gender bias in China, South Korea and India 1920–1990: effect of war, famine and fertility decline. *Development and Change* **30**(3), 619–652.

Dreze, J. & Murthi, M. (2001) Fertility, education and development: evidence from India. *Population and Development Review* **27**(1), 33–63.

George, S. M. (1997) Female infanticide in Tamil Nadu, India: from recognition back to denial? *Reproductive Health Matters* **5**(10), 124–132.

Guilmoto, C. Z. (2009) The sex ratio transition in Asia. *Population and Development Review* **35**(3), 519–549.

Guilmoto, C. Z. & Rajan, S. I. (2001) Spatial pattern of fertility transition in Indian districts. *Population and Development Review* **27**(4), 713–738.

Guilmoto, C. Z. & Rajan, S. I. (2002) District level estimates of fertility from India's 2001 Census. *Economic and Political Weekly* **37**(7), 665–672.

IIPS (2006) *District Level Household Survey–II (2002–04)*. International Institute for Population Sciences, Ministry of Health and Family Welfare, Government of India, Mumbai.

IIPS (2010) *District Level Household and Facility Survey–III (2008–09)*. International Institute for Population Sciences, Ministry of Health and Family Welfare, Government of India, Mumbai.

Jha, P., Kesler, M. A., Kumar, R., Ram, F. & Ram, U. (2011) Trends in selective abortions of girls in India: analysis of nationally representative birth histories from 1990 to 2005 and census data from 1991 to 2011. *The Lancet* **377**, 1921–1928.

Jha, P., Kumar, R. & Vyas P. (2006) Low male-to-female sex ratio of children born in India: national survey of 1.1 million households. *The Lancet* **367**, 211–218.

Kulkarni, P. M. (2012) Recent trends in sex composition of the population of Gujarat. Paper presented at *Making Sense of Census 2011 for Gujarat* conference organized by the Gujarat Institute of Development Research, Ahmadabad, 28th December 2012.

Kumar, S. & Sathyanaraynana, K. M. (2012) District level estimates of fertility and implied sex ratio at birth in India. *Economic and Political Weekly* **47**(33), 66–72.

Kuzhiparambil, A. & Rajani B. M. (2012) Epicentres of missing daughters geo-spatial dimensions of the child sex ratio in India. *Asian Population Studies* **3**(8), 265–280.

McNay, K., Arokiasamy, P. & Cassen R. H. (2003) Why are uneducated women in India using contraception? A multilevel analysis. *Population Studies* **57**(1), 21–40.

Mohanty, S. K. & Ram, F. (2011) Spatial pattern of poverty reduction and fertility transition in India. *Population Review* **50**(1), 62–78.

Murthi, M., Guio, A. C. & Dreze, J. (1995) Mortality, fertility and gender bias in India: a district-level analysis. *Population and Development Review* **21**(4), 745–782.

Navaneetham, A. & Dharamalingam, A. (2011) Demography and development: preliminary interpretation of the 2011 census. *Economic and Political Weekly* **46**(16), 13–17.

Ram, F., Shekhar, C. & Mohanty, S. K. (2005*) Human Development: Strengthening District Level Vital Statistics in India.* International Institute for Population Sciences, Mumbai.

Roy, T. K. & Chattopodhyay, A. (2012) Daughter discrimination and future sex ratio at birth in India. *Asian Population Studies* **8**(3), 281–99.

RGI (1988) *Child Mortality Estimates of India, Census of India 1981*. Occasional Paper No. 5. Office of the Registrar General, India, New Delhi.

RGI (1989a) *Child Mortality, Age at Marriage and Fertility in India, Census of India 1981*. Occasional Paper No. 2. Office of the Registrar General, India, New Delhi.

RGI (1989b) *Fertility in India: An Analysis of 1981 Census Data.* Occasional Paper No. 13 of 1988. Office of the Registrar General, India, New Delhi.

RGI (1994) *Report on Post Enumeration Check.* Paper 1 of 1994, Series 1. India. Registrar General and Census Commissioner, Office of the Registrar General, India, New Delhi.

RGI (1997) *District Level Estimates of Fertility and Child Mortality for 1991 and their Interrelations with Other Variables.* Occasional Paper No. 1 of 1997. Office of the Registrar General, India, New Delhi.

RGI (2009a) *District Level Estimates of Child Mortality in India Based on the 2001 Census Dat*a. Registrar General and Census Commissioner, Office of the Registrar General, India, New Delhi.

RGI (2009b) *District Level Estimates of Child Mortality in India Based on 2001 Census Data*. Office of the Registrar General, India, New Delhi.

RGI (2011a) *Provisional Population Total.* Paper 1 of 2011. India Series 1, Census of India 2011. Office of the Registrar General and Census Commissioner, Government of India.

RGI (2011b) *Annual Health Survey Bulletins 2010–11.* Office of the Registrar General and Census Commissioner, Government of India. URL: http://censusindia.gov.in/2011-common/AHSurvey.html

RGI (2012) *Sample Registration System Statistical Report 2012*. Report No. 1 of 2012. Office of the Registrar General, Government of India, New Delhi.