Sex ratio at birth in India: new evidence from NFHS-4

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Abstract

We examined the factors associated with SRB using fourth round of National Family Health Survey (NFHS-4). The SRB at birth order 1 was 107.5. *South* India, which was never known for sex-selection, also had an SRB of 107.5. At birth order 1, the probability of male birth was associated with middle and richest wealth quintiles, lower fertility at community level, and residing in *central* and *east* regions. Most SRB correlates are visible for parity 2 or 3+. Among birth orders 2 and 3 or higher, the probability of a male birth among land owning households was higher compared with households who did not own land. Mothers not having a previous son and mothers who reported higher ideal number of sons than daughters were more likely to have a male birth compared with their counterparts. Fertility in the immediate neighborhood was negatively associated with the probability of male birth in regressions.

Background

The debate around sex ratio of children age 0-6 years in India is decades old and acquired prominence during early 1990s with the publication of the article "more than 100 million women are missing" by the Noble Laureate Amartya Sen (Sen 1990). It had a compelling narrative about sex selective abortions and preference for sons in the Asian countries particularly India. Other scientific literature has also established that India and China are the countries that account for most of the world's female deficit (Klasen and Wink 2002; Bongaarts and Guilmoto 2015; Guilmoto et al. 2018). It has also been established beyond reason that the sex ratio of children age 0-6 years in India has been in favor of males for a long time (Bhat and Zavier 2007; Office of Registrar General of India 2011; Arokiasamy 2007; Arokiasamy and Goli 2012; Premi 2001; Mishra et al. 2009). According to the most recent Indian census, the sex ratio of children was 109 males per 100 females (Office of Registrar General of India

2011). More worrisome is the fact that the sex ratio of children increased from 106 in 1991 to 108 in 2001 and further to 109 in 2011 (Jha et al. 2011; Rajan, Srinivasan and Bedi 2015). Researchers often attribute such a high sex ratio of children to various factors including high sex ratio at birth (SRB) as well as excess female mortality during the early years of life (Visaria 1971; DasGupta and Bhat 1997; Sudha and Rajan 1999; Arnold, Kishore and Roy 2002; Mishra et al. 2009).

Interestingly, time series data from the sample registration system (SRS) indicates that sex differential in mortality has narrowed down in the recent years. The recently conducted National Family Health Survey 2015-16 (NFHS-4) indicates lower under-five mortality rate among females compared to males - 48 versus 52 (IIPS and ICF 2017). Despite the narrowing of sex differentials in mortality in the last few decades, the sex ratio of children age 0-6 has been rising steadily in India. A recent study reported an excess female under-5 mortality rate of 18.5 per 1,000 live births in India in 2000-2005 which corresponds to an estimated 239,000 excess female deaths per year (Guilmoto et al. 2018). Although, the excess female under-5 mortality rate in India is a matter of concern, the toll of excess female deaths has been declining in India since the 1970 (Bongaarts and Guilmoto 2015). In a scenario in which the sex differentials in mortality are narrowing down dramatically and no sign of increase in the excess female under-5 deaths (Bongaarts and Guilmoto 2015; Hill and Upchurch 1995; Alkema et al. 2014), the rising trend in sex ratio of children age 0-6 years can only be explained by high SRB.

Under normal circumstances, SRB varies between 103 and 106 (Visaria 1971; United Nations Secretariat 1998), the average estimated value being 105 male births per 100 female births (Bongaarts 2013; Dyson 2012). However, recent data from the SRS indicates an SRB of 111 for the year 2015 (Office of the Registrar General of India 2016). Also, trend in sex ratio at birth in the last 10 years indicates that the SRB varied between 110 and 112. Researchers mostly attribute the high sex ratio at birth to incidences of sex selective abortions in regions where son preference remains strong (DasGupta and Bhat 1997; Sudha and Rajan 1999; Arnold, Kishore and Roy 2002; Roy and Chattopadhyay 2012; Bongaarts 2013). On the contrary, Bhat and Zavier (2007) concluded that only a minority misuse prenatal diagnostic techniques (PNDT) for aborting female fetuses. Bhat and Zavier (2007) further concluded that the misuse of PNDT is governed more by cultural factors and the sex composition of children already born rather than socio-economic factors like income and education. Some researchers have also attributed the possible increase in SRB to decline in the proportion of higher-order births (Bhat 2002; Guilmoto 2009).

There are only a few studies that have examined the association between demographic, kinship structure, socio-economic, residence-related factors, and use of technology such pre-natal diagnostic techniques (PNDT) with SRB. Studies have documented several socio-economic and development indicators to be associated with high SRB in India. Guilmoto and Ren (2011) using National Family Health Survey (NFHS) 2005-06 show strong positive association between socio-economic status and SRB. Jha et al. (2011) also reported similar relationship. Agnihotri (2003) and Siddhanta et al. (2003) show positive association between level of expenditure and birth masculinity. A geostatistical analysis by Guilmoto (2008), using 2001 census district-level data, found economic development as one of the major correlates of SRB. On the contrary, Bhat and Zavier (2007) found no association between standard of living and birth masculinity. Birth order, urban residence, educational level, religion, caste or tribe failed to show significant or consistent association with SRB in the study by Bhat and Zavier (2007). However, Echavarri and Ezcurra (2010) found inverted U-shaped relationship between education and SRB in India. Maternal age was associated with SRB in NFHS 1992-93 but not in NFHS 1998-99 (Bhat and Zavier 2007). Compared to the south region, north region had higher SRB even after adjusting for several socio-economic, demographic, and PNDT factors (Bhat and Zavier 2007; Bhat 2002; Arokiasamy 2007; Sudha and Rajan 1999; Guilmoto 2008).

Bhat and Zavier (2007) found independent effects of sex composition of previously born children and use of PNDT on SRB. Women having no previously born male children were more likely to have a male birth compared to women who already have a previously born male child. Women reporting use of PNDT were also more likely to have a male birth compared with women who did not use PNDT. Studies have also revealed association between low fertility and high SRB. In India, the dual desire for small families and male children puts considerable pressure on sonless couples to sex select at lower parities (Guilmoto 2009; DasGupta and Bhat 1997). Studies have also shown that distortion in SRB is particularly pronounced at higher order births, when only daughters were born previously (Bhat 2002; Bhat and Zavier 2003; Jayaraj 1999; Retherford and Roy 2003). Another study by Jayachandran (2017) revealed that fertility decline could explain up to half of India’s sex ratio increase during 1981-2011. Kinship structures are often used effectively in demographic research (Chakraborty and Kim 2010;

Dyson and Moore 1983; Todd 1985) as they are a clear sign of nature of gender arrangements in a population (Dube 1997; Kaser 2008). Studies relating kinship structure and SRB reveal mixed findings. While, lower SRB was observed among women who were married to close relatives compared with women married to non-relatives in the study by Jayaraj (1999), SRB was not associated with consanguinity in marriage in the study by Bhat and Zavier (2007).

Although, SRB is such an important demographic issue in India, there are only a few attempts to understand the factors associated with SRB in India. A notable attempt in this direction was by Bhat and Zavier (2007) who used data from the NFHS 1992-92 and NFHS 1998-99 for examining the factors influencing SRB in India. To the best of our search, we could not find any other study which examines SRB in India in the recent period. Though Bhat and Zavier (2007) demystified a lot of factors associated with sex ratio at birth, the study did not stratify SRB by birth order. Also, Bhat and Zavier (2007) did not include certain important variables like landholding size of households, kinship structure related variables like - type of household (nuclear, non-nuclear), presence of an elderly women in the household, child marriage -, level of fertility in the immediate community, and so forth in the analysis. A study by Arokiasamy and Goli (2012) found significant association between landholding size and sex ratio of children age 0-6 years in rural India. Given the above, we in this paper examine the factors associated with SRB in India using the recently released NFHS 2015-16 (henceforth referred to as NFHS-4) dataset. We examine the factors associated with SRB stratified by birth order. Usually, sex selection for son happens less frequently at birth order 1, and increases with an increase in birth order particularly among couples who do not have a previously born son. A stratified analysis by birth order is likely to inform any changes in patterns of sex selection for son by birth order in the recent past. We also explore for possible spatial autocorrelation in SRB at the district level. We base our analysis on births that occurred between 2005 and 2016 to examine the associations in the recent past.

Data and Methods

Our analysis is based on 553,461 births that occurred between 2005 and 2016 in 601,509 households interviewed in NFHS-4. The NFHS-4 is a nationally representative household survey conducted across the 29 States and 6 Union Territories of India. The NFHS-4 used two-stage sampling design in both urban and rural areas. In rural areas, villages were selected in first stage using probability proportional to size (PPS) scheme. Households were selected in second stage using systematic sampling. In urban areas, census enumeration blocks (CEBs) were selected in first stage using PPS scheme and households selected in second stage using systematic sampling. The key objectives of NFHS-4 are to provide state- and district- level estimates of fertility, mortality, family planning, maternal and child health indicators, etc. The NFHS-4 also collected information on use of ultrasound for pregnancies in the past 5 years preceding the survey. The household and individual response rates in NFHS-4 were 98% and 97%, respectively. Since the NFHS-4 follows a two-stage design, the estimates are representative only after weighting. The details of NFHS-4 can be found elsewhere (IIPS and ICF 2017).

We used the births occurred between 2005 and 2016 to estimate SRB by various socio-economic, demographic, residence-related, kinship structure related variables, and use of ultrasound technology. We also estimated the 95% confidence intervals (CIs) for the estimated SRBs. SRB in this paper is defined as male births per 100 female births. The details of the variables included in the analysis are shown in **Table 1**. Traditional kinship structures play a major role in determining the bargaining power of women in developing countries like India (Agarwal 1994, 1997; Folbre 1997; Miller 1981). For example, women's bargaining position is likely to be lower in societies where cross-cousin marriages are not allowed or where child marriages are encouraged and supported (Agarwala 1957; Agarwal 1994; Mathur 2007). We included three variables - consanguineous marriage, child marriage, and household structure – to account for the role of kinship structure in determining the SRB in India. Consanguineous marriage is defined as a marriage where the (current) husband is related to the wife in any way before she got married. If the woman reported yes, then consanguineous marriage was coded as '1'. Otherwise, consanguineous marriage was coded as '0'. Child marriage is defined as a marriage/cohabitation (whichever is earlier) when woman was younger than age 18. A nuclear household has many benefits over a non-nuclear household. Although it lacks support system, it offers greater freedom to the individual household members. Living in a nuclear household also facilitates greater exposure to things in everyday life which may lead to greater awareness and knowledge (Larsen, Gooch and Hatti 2005). Relatedly and importantly, mothers-in-law were found to have an important influence on family decisions pertaining to activities within the household in a study by Char, Saavala and Kulmala (2010) in rural Madhya Pradesh, India. Mothers-in-law were also likely to influence the number of sons their daughters-in-law had and the timing of their daughters-in-law being sterilized. Anecdotal evidence also suggests that mothers also at times put pressure on their daughters to bear sons. To account for the influence of mothers-in-law or mothers, we constructed a variable related to presence of an elderly women (60+) in the household.

The demographic variables included in the analysis are age of the mother, birth order of the child, and the presence of a previously born son. We also included mother's education in the analysis. In addition, Bhat and Zavier (2007) included ideal number of children as one of the independent variable in the analysis. However, Bhat and Zavier (2007) noticed spurious relationship between ideal number of children and the SRB. They argued that those who had sons tend to use contraception more than those who had daughters; in order to justify their non-use of contraception, the latter group has the tendency to report higher ideal number of children. There is also a possibility of endogeneity in the sense that if a couple has one child and it's a boy, then the couple is likely to claim one child as the ideal in response to the question on ideal number of children. To avoid the above mentioned biases associated with ideal number of children, we included a variable related to difference between the ideal number of sons and daughters. This variable is less likely to be affected by endogeneity or ex post rationalization (Bhat and Zavier 2003). If the difference was less than or equal to zero, then this variable was coded as '0'. Otherwise it was coded as '1'. We also estimated average number of children per woman at the primary sampling unit (PSU) level. Note that PSU in rural and urban areas are the villages and CEBs. Average number of children per woman at the PSU level reflects on the level of fertility in the immediate neighborhood. As done in the previous studies, we also included a variable on use of ultrasound technology in pregnancies in past five years preceding NFHS-4 to account for the role of PNDT in influencing the SRB.

We included three variables – wealth index, caste, and religion – to capture the socio-economic status of the households. The wealth index, already given in the NFHS-4 dataset, is a principal component analysis-derived index of household assets and amenities (IIPS and ICF 2017). Caste is coded into four categories namely "scheduled castes (SC)", "scheduled tribes (ST)", "other backward class (OBC)", and others. The *SC*, *ST*, and *OBC* are considered socially and economically backward by the Constitution of India, and hence derive various privileges and benefits. In India, "Hindu" is the dominant religious group followed by "Muslim" and "Christians". There are smaller religious groups like "Sikhs", "Jains", "Buddhist/neo-Buddhist", etc. (Office of the Registrar General of India 2011). Based on the sample sizes, religion was classified into "Hindu", "Muslim", "Christian", "Sikh", "Buddhist/neo-Buddhist", and "others". In order to capture the geographic region level differentials in SRB, we classified India into six state-regions – North, Central, East, Northeast, West, and South. North consists of Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, and Uttarakhand. Central consists of Chhattisgarh, Madhya Pradesh, and Uttar Pradesh. East consists of Bihar, Jharkhand, Odisha, and West Bengal. Northeast consists of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. West consists of Dadra & Nagar Haveli, Daman & Diu, Goa, Gujarat, and Maharashtra. South consists of Andaman & Nicobar Islands, Andhra Pradesh, Karnataka, Kerala, Lakshadweep, Puducherry, Tamil Nadu, and Telangana. Finally, we coded land holding size of the household into four categories – no land, up to 10 acres, more than 10 acres, and land unit not defined.

Further, we fitted binary logistic regression models to examine the association between variables listed in **Table 1** and the probability of a male birth. We fitted separate logistic regression models for birth orders 1, 2, and 3 or higher. In the regression models, we also examine the effect of interaction between use of ultrasound technology during pregnancy and presence of a male sibling on the probability of a male birth. To further explain the relationship between use of ultrasound technology and the probability of a male birth we looked at the sex composition of unwanted births among mothers who had ultrasound and who did not for births occurred in past 5 years preceding NFHS-4. We used the following two questions canvassed in NFHS-4 to identify unwanted births among the two groups of mothers:

1. When you got pregnant with (Name), did you want to get pregnant at that time? (Yes/No)
2. Did you want to have a baby later on, did you not want any (more) children? (Later/No more)

Births whose mothers reported 'No' to question 1 and 'No more' to question 2 were coded as 'unwanted'. The rest were coded as 'wanted'.

For exploring the spatial autocorrelation, we predict residuals using the binary logit models averaged at the district level. We then estimate Moran's I to examine spatial autocorrelation in the predicted residuals. We also estimated univariate Local Indicators of Spatial Association (LISA) maps to examine spatial clustering in the predicted residuals averaged at the district level. This analysis was conducted to rule out the presence of unobserved spatially autocorrelated factors. All the analysis except mapping, calculation of Moran's I, and estimation of LISA was conducted in STATA 15.0. Moran's I was calculated using GeoDa. Moran's I is a correlation coefficient that measures the overall spatial autocorrelation present in the data. Univariate LISA measures the correlation of neighborhood values around a specific spatial location; essentially determining the extent of spatial clustering (Anselin 1995; Anselin 2005).

Results

SRB in districts of India

Figure 1 shows the spatial distribution of SRBs at the district level in 2001 and 2011 Indian Censuses. In 2001, high SRBs (i.e. above 110) were mostly clustered in districts of Punjab, Haryana, Delhi, Gujarat, and Maharashtra. A considerable number of districts from Himachal Pradesh, Uttar Pradesh and Madhya Pradesh also had SRBs above 110. Importantly only a few districts from Andhra Pradesh, Karnataka, and Tamil Nadu depicted SRBs above 110. Likewise, a few districts from Odisha, Chhattisgarh, Bihar, Jharkhand, and northeastern states depicted SRBs above 110. In 2011, while the spatial distribution was largely similar but the districts with high SRBs were more scattered. Interestingly, more districts from the southern, eastern and northeastern states, earlier not known for sex selection, join the high SRB group. A few districts of Jammu and Kashmir also joined the high SRB group in 2011. A few districts from Rajasthan, Gujarat and Madhya Pradesh move from high SRB group to moderate (105 – 109) group and normal (100 – 105) group. Kerala is the only state that did not see noticeable change in district SRBs between 2001 and 2011.

Bivariate results

Table 1 shows SRB by selected socio-economic, demographic, residence-related, kinship structure-related, and use of ultrasound-related variables along with 95% CIs. Absence of a surviving male sibling is one of the important determining factors of SRB in India. In our analysis, SRB in presence of a surviving male sibling was 105.8 which is well within the normal limits. However, SRB in absence of a surviving male sibling was 111.4 which is much above the normal limits. SRBs in presence and absence of a surviving male sibling are statistically different. Use of ultrasound technology was associated with SRB among mothers who delivered in last five years preceding NFHS-4. SRB among mothers who used ultrasound technology was significantly higher compared with SRB among mothers who did not use (112 versus 105). Moreover, SRB in absence of use of ultrasound was within the normal limits.

Of the four kinship structure-related variables, only household structure and presence of an elderly woman in the household were statistically associated with SRB in the bivariate analysis; the SRB being lower in nuclear households and in households in which no elderly woman is present. SRB increased with an increase in mother's schooling; SRB was significantly lower among mothers with no schooling compared with mothers having schooling up to secondary level or higher. SRB also varied considerably by difference between ideal number of sons and daughters. SRB among mothers who reported equal number of sons and daughters as ideal or more daughters than sons as ideal was 103.3, which is within the normal limits. In comparison, SRB among mothers who reported more sons than daughters as ideal was 130.4. Birth order effect is also an important dimension of SRB differentials in India. SRB increased with an increase in birth order; SRB at first birth order was statistically different from SRB at birth orders 3 and 4 or higher. Surprisingly, the SRB at birth order one was 107 which is far above the normal for first births in India.

SRB varied considerably by wealth index; SRB is lowest among the poorest quintile (105.8) and highest among the richest quintile (116). Moreover, SRB in poorest quintile differed significantly from the SRB in richest quintile. SRB is lowest among *SC* followed by *ST*, *OBC*, and *others*. SRB also varied considerably by religion of the household head. SRB was highest among the *Sikhs* (116.9). SRB was also considerably high among the *Buddhist/Neo-Buddhist* (114.6). SRB was lowest among the *Christians* (106.2). Place of residence, measured in terms of urban-rural residence, was also associated with SRB in the bivariate analysis; the SRB being higher in urban (111.4) compared with rural (108.8) areas. Interestingly results emerge when we examine differentials in SRB by geographic region of residence. SRB was highest in the *north* (116.0) and lowest in the *north-east* (105.8). SRB was also considerably high in the *west* (111.4) and the *central* regions (109.2). Interestingly, *south* which was never known for sex selection also appears to have a SRB that is outside the normal range (107.5).

An important variable that is associated with SRB in the Asian context is the fertility. In our study, average number of children per woman in the immediate community was statistically associated with SRB. The SRB is well within the normal range when fertility is above 2.8 children per woman (103.7). It jumps to 112 among mothers living in communities where average fertility is below 1.5 children per woman. Moreover, SRB increased consistently with decline in fertility. A characteristic that is often less examined for the want of data is the patriarchy customs and norms at the household level. A number of studies from south-east Asia have identified landholding size of households as a proxy of patriarchal customs and norms. Indeed, the SRB increased with increase in landholding size of households. The SRB among mothers residing in households with landholding size more than 10 acres was 112.3 whereas it was 108.8 among mothers residing in households having no landholding.

Multivariate results stratified by birth order

Multivariate results are presented in **Table 2**. Since the SRB varies considerably by birth order, we estimated separate binary logistic regression models for birth order 1, birth order 2, and birth order 3 or higher. The bivariate results (shown in **Table 1**) indicate that SRB at birth order 1 in India is not random. If it is for real, it should be responsive to some socio-economic status variables because only the upper socio-economic classes would care to sex-select for the first pregnancy. The binary logistic regression results for birth order 1 suggest that the probability of a male birth is indeed responsive to a few variables. The probability of a male birth was associated with higher wealth quintiles - the mothers from middle and richest quintiles were more likely to have a male birth compared with mothers from poorest quintiles. Likewise, mothers who reported higher ideal number of sons than daughters were 1.69 (95% CI: 1.64 – 1.74) times as likely as mothers who reported other combinations to have a male birth. The probability of having a male birth was also higher among mothers in communities where the average number of children per woman was less than or equal to 2.2 compared with mothers in communities where the average is greater than 2.8. Finally, mothers from the *central* and the *east* regions were significantly less likely to have a male birth compared with mothers from the *south*.

Like birth order 1, a few variables were only associated with the probability of a male birth at birth order 2. Absence of a male child was associated with a higher probability of male birth. Mothers who had no son were 1.15 (95% CI: 1.12 – 1.18) times as likely as mothers who had a son to have a male birth. Mothers from richest quintiles and mothers who reported higher ideal number of sons than daughters were more likely to have a male birth compared with their counterparts. The effect of average fertility at the community level became stronger at birth order 2. Interestingly, mothers from households having 10 acres or more land were 1.07 (95% CI: 1.03 – 1.11) times as likely as mothers from households who do not own land to have a male birth. Interestingly, mothers belonging to *SC*, *ST*, or *OBC* communities were less likely than mothers belonging to *Other* communities to have a male birth. Muslims were less likely than Hindus to have a male birth (Odds ratio – 0.96; 95% CI: 0.91 – 1.00).

Most SRB correlates are visible at birth order 3 or higher. The probability of a male child was significantly associated with mother's schooling. Mothers with more than secondary schooling were 1.25 (95% CI: 1.13 – 1.39) times as likely as mothers with no schooling to have a male birth. Likewise, mothers with up to secondary schooling were 1.07 (95% CI: 1.04 – 1.11) times as likely as mothers with no schooling to have a male birth. Mothers from middle, richer, and richest quintiles were more likely to have a male birth compared with mothers from poorest quintiles. Mothers from the *north*, *central*, *east*, *northeast*, and *west* regions were more likely to have a male birth compared to mothers from the *south*. While Muslim mothers were less likely than Hindu mothers to have a male birth (Odds ratio – 0.96; 95% CI: 0.93 – 0.99), Sikh mothers were more likely than Hindu mothers to have a male birth (Odds ratio – 1.13; 95% CI: 1.00 – 1.28). Absence of a previous son, difference in the reported ideal number of sons and daughters, landholding size of household, and average fertility at the community level were also associated with the probability of a male birth. Subsequent analysis (**results not shown here**) shows that the probability of a male birth increases with increase in the number of previous daughters. For example, mothers having one daughter were 1.06 (95% CI: 1.02 – 1.09) times as likely as mothers having no daughters to have a male birth. But, mothers having two or three or more daughters were 1.16 (95% CI: 1.12 – 1.21) and 1.18 (95% CI: 1.13 – 1.23) times as likely as mothers having no daughter to have a male birth.

Effect of use of ultrasound technology

Table 3 shows the results of interaction between use of ultrasound technology and absence of a previous son. The interaction term was significant in both the models indicating that mothers who had no son and used the ultrasound technology were more likely to have a male birth compared with mothers who had son(s) and did not use ultrasound technology. Moreover, in model 2, among those who had previous sons mothers who used ultrasound technology were 1.08 (95% CI: 1.03 – 1.13) times as likely as mothers who did not use ultrasound to have a male birth. The probability of a male birth was also associated with the absence of previous son(s) among those mothers who have not used ultrasound technology (Odds ratio – 1.08; 95% CI: 1.03 – 1.14). We also examined the interaction effect of use of ultrasound technology and number of surviving female siblings (Results not shown). The interaction term was strong and statistically significant (Odds ratio – 1.10; 95% CI: 1.07 – 1.14). The probability of a male birth increased with an increase in the number of surviving female siblings among the mothers who have not used ultrasound technology (Odds ratio – 1.03; 95% CI: 1.01 – 1.05).

Among mothers who did not use ultrasound technology, girls constituted 53% of the unwanted births. In contrast, among mothers who used ultrasound technology, girls constituted less than half (49.6%) of the unwanted births. The picture is even more clear when we only look at the sex composition of most recent unwanted births among the two groups of mothers. Among mothers who did not use ultrasound technology, girls constituted 53% of the unwanted births. In comparison, among mothers who used ultrasound technology, girls constituted only 48% of the unwanted births. In societies where boys are preferred over girls, girls constituting less than half of unwanted births among mothers who had used ultrasound technology is only likely when a considerable proportion of female fetuses were aborted post use of ultrasound technology.

Accounting spatial autocorrelation

Past studies have reported considerable spatial autocorrelation in sex ratios at the district level. In the presence of spatial autocorrelation, the results obtained from classical statistical analysis are likely to be biased. To check for spatial autocorrelation, we estimated Moran's I using the predicted residuals averaged at the district level. Moran's I for predicted residuals averaged at the district level was 0.12 for all births. Moran’s I for birth orders 1, 2, 3 or higher were 0.06, 0.04, and 0.03 respectively. Such low values of Moran’s I indicate near absence of spatial autocorrelation in the residuals. Even LISA maps showing predicted residuals averaged at the district level do not depict any spatial clustering of the residuals (**Figure 2**). So, we believe that the coefficients presented in **Tables 2 and 3** are robust to the spatial autocorrelation of residuals at the district level.

Discussion

Our is perhaps the first study that presents robust estimates of SRB in India by various socio-economic, demographic, residence-related, kinship-related variables, and use of ultrasound technology. Our study also examined the factors associated with SRB stratified by birth order in India using over 550,000 births between 2005 and 2016. Our is also perhaps the first study that provides 95% CIs for the estimated SRBs in India. Based on births between 2005 and 2016, we estimate a SRB of 109.2 for India. According to the Sample Registration System (SRS) of India, the SRB for the period 2005-15 was 110.7

which is close to the estimate presented in this paper. The District Level Household Survey 2007-08 (DLHS-3) provides an estimate of SRB of 109.6 for the period 2004-2008 (IIPS 2010). While the 2001 Indian Census provided an estimate of 110.4 (based on births during the preceding year), 2011 Indian Census provided an estimate of 111.2 (based on births during the preceding year). In the light of the evidence presented above, our estimate of SRB seems plausible. Such high levels of SRB in India is also plausible in the light of very high SRB in other countries marked by considerable son preference. For example, the SRB for China from the 2005 intercensal survey was 120.5 and official estimate for 2009 was 119.5. The first 2010 census estimate is 118.1 (Li, 2007; Li et al., 2007; NSB, 2010). The SRB in Vietnam also reached to as high as 113.8 in 2013. While in South Korea, the SRB declined from as high as 116.5 in 1990 to 106.2 in 2007 (Boer and Hudson 2017).

A key finding that deserves mention relates to SRB at birth order 1. The SRB at birth order 1 was 107.5 which is above the normal limit. The only study from India that provides comparable estimate of SRB at birth order 1 is by Bhat and Zavier (2007). Bhat and Zavier (2007), using all births from NFHS 1998-99 (NFHS-2) reported an SRB of 106.9 at birth order 1. Our estimated SRB at birth order 1 is also close to the estimated SRB (108.0) at birth order 1 in China in 2005 (Guilmoto and Ren 2011). The SRB at birth order 1 in Vietnam in 2011 was of the order of 109.7 which is far above the normal upper limit (Boer and Hudson 2017). The experience of other countries indeed suggests that the high values of SRB at birth order 1 in India is plausible given that India is also affected by considerable son preference. There is also a possibility in societies highly affected by son-preference that the mother reports her son(s) first and then the daughter(s). However, with the NFHS-4 questionnaire, this is unlikely to happen. Moreover, it is even more difficult when the questionnaires in NFHS-4 were canvassed using Computer Assisted Personnel Interviewing (CAPI). If the mother has to report son(s) first and then daughter(s), then she has to wrongly but consistently report the month and year of birth and the age of each son and daughter. In case of an inconsistency between month and year of birth and age of a child, the CAPI will not allow the field interviewer to move ahead. Such a thoughtful manipulation of month and year of birth and the age of the child on the part of the mother is highly unlikely. In addition, to further rule out this possibility, we estimated the percentage of male births out of total births at birth orders 1, 2, 3, and 4 or higher. If the mother systematically reports sons first and then daughters, then the percentage of male births at birth order 1 and 2 should be higher than percentage of male births at birth orders 3 or 4 or higher. The percentage of male births at birth orders 1, 2, 3, and 4 or higher were

51.8, 52.0, 53.6, and 52.3, respectively; these percentages do not indicate any mis-reporting of birth order by mothers in NFHS-4. Despite that, a SRB of 107.5 at birth order 1 in India does not seem to be random. In that case, the SRB at birth order 1 must be responsive to a few selected socio-economic variables. Results indeed suggest that the SRB at birth order 1 was responsive to a few selected socio-economic variables. The probability of a male birth was associated with middle and richest wealth quintiles, lower fertility at community level, and residing in the *central* and *east* regions. Interestingly, most SRB correlates are visible for parity 2 or 3+. Since the SRB at birth order 1 is not associated with education, religion, etc., the possibility of exaggeration of SRB or underreporting of female children - due to their lesser value in the household - at birth order 1 in India cannot be completely ruled out.

A few findings appear to be novel. For example, southern India that was never known for sex-selection had a SRB of 107.5. While a SRB of 107.5 seems high for the *south*, the SRB from other sources like the Census of India and the SRS confirm this finding. Census of India indicates that the SRB at birth in the *south* has increased from 106 in 2001 to 107 in 2011. The Sample Registration System (SRS) provides an SRB of 107.4 for the period 2005-2016. These evidence indicate that couples in the *south* that were never known for sex selection are also adopting sex selection, although to a much lower level compared to the *north*, *central*, and *west* regions of India, to have sons. This could also be the result of low fertility in *south* India. The total fertility rate (TFR) in all the five states belonging to the south have fertility levels much below the replacement level. For example, the TFR in Kerala in NFHS-4 was 1.56. Among the south Indian states, TFR was highest in Andhra Pradesh at 1.83 (IIPS and ICF 2017). Second, we do find evidence to support the landholding patriarchy hypothesis. At birth orders 2 and 3 or higher, couples holding 10 or more acres of land were more likely to have a male birth compared to couples having no land. This result is consistent with the study by Arokiasamy and Goli (2012) who also noticed that sex ratio of child population was in favor of males compared with females among couples owning 10 or more acres of land in rural areas. As landholding size is more meaningful in rural areas, we did run the regression models for rural area separately. The results were similar though a bit stronger. Our findings are also consistent with studies from China where the SRB was considerably high in mothers who were engaged in land-based occupation (Guilmoto and Ren 2011). Moreover, land reforms accounted for roughly half of increase in sex ratios in rural China from 1978-86 (Almond, Li and Zhang 2019). In China, the land reforms brought back the son-preference that has been submerged by communal land ownership, where people could not pass on their land to their children, and where the old age support was to a certain extent provided by the commune. The market economy after the land reforms increased the importance of sons in China. Banister (2004) also argued for carefully understanding the system of landholding and transmitting land and property rights within families to explain shortage of girls in China. Landholding might affect SRB in many ways. While Arokiasamy and Goli (2012) argue that daughters have weak ties with their natal families after marriage due to restriction of land rights to males of patrilineal clan, Guilmoto and Ren (2011) argue that women are economically valued less in landed households. Arokiasamy and Goli (2012) also reported lower female autonomy in large landholding households. Although, we do find evidence of landholding patriarchy hypothesis in India, the situation in India is a bit different than that in China during or immediately after the land reforms. In China the ultrasound technology was increasingly available in provincial capitals since the early 1970s; China began restricting the use of ultrasound technology for sex determination in 1986 (Almond, Li and Zhang 2019). Soon after India issued such prohibitions. In India, it has been the sons who inherit the land, and parents depend largely on their sons for old-age support.

Interestingly, geographic region of residence was also statistically associated with probability of male birth. At parity 3 or higher (where the effect of most of the covariates are visible), SRBs in the other regions were higher than that in the *south* even after adjusting for selected variables. This clearly indicates that women in other regions misused the technology more than women in the *south*. The systematic pattern in the significance of geographic region dummy variables also indicates towards the strong role that regional-cultural differences in preference for sons might play in affecting the SRB. Moreover, these regional differences do not appear to be an artifact of variations in data quality. Despite these, role of some genetic factors and underreporting of female births in other regions in explaining regional variations cannot be completely ruled out. In regression models at birth order 2 and 3 or higher, Muslim women were less likely than Hindu women to have a male birth. At birth order 3 or higher, Sikh women were more likely than Hindu women to have a male birth even after adjusting for selected variables. Previous research has also shown distorted sex ratio in Punjab where Sikh religion is the predominant religion (Office of the Registrar General of India 2011; Bhat and Zavier 2007). Studies have also shown that while Sikhs have a stronger preference for sons than Hindus, Muslims have lower preference for sons than Hindus (Bhat and Zavier 2003; Bhat 2002; Das Gupta 1987; Miller 1981).

Importantly, the interaction of ultrasound technology and absence of a previous son was statistically significant in the regression models. Mothers of recent births who did not have a previous male child and underwent ultrasound were significantly more likely than mothers who had sons and did not use ultrasound to have a male birth. Notice that women in male selection situation (that is having a child but not having a male child) had high SRB even in absence of ultrasound technology; a finding that is consistent with Bhat and Zavier (2007). This finding clearly indicates that some women must have suppressed the use of ultrasound technology during the most recent birth in NFHS-4. Use of ultrasound technology was also associated with higher SRB in the study by Arnold, Kishore and Roy (2002). The results related to the sex composition of unwanted births among women who used ultrasound technology and who did not clearly indicate that a considerable proportion of women used ultrasound technology to know the sex of the fetus. Results also indicate that a small proportion of female fetuses were aborted post use of ultrasound technology. Relatedly, mothers who reported higher number of sons than daughters as ideal were more likely to have a male birth compared to mothers who reported other combinations. This finding indicates that mothers who report higher number of sons than daughters as ideal are more likely to sex-select than other mothers. It also indicates that the question on ideal number of sons and daughters as implemented in surveys is a valid predictor of gender bias in settings deeply affected by son preference unless it is purely endogenous and women rationalize their preferences ex post. This variable seems more problematic in low fertility societies than in high fertility societies as in low fertility societies women are more likely to report “one son and one daughter” as ideal, concealing potential aversion for two daughters or preference for two sons. Previous evidence from India suggests that such biases do not seriously affect the systematic variations in the preference for sons (Bhat and Zavier 2003). Bhat and Zavier (2003) showed that the pattern of son preference revealed by such data corresponds closely to what is already known about women’s empowerment and discrimination against women.

Fertility in the immediate community was also associated with probability of male birth. Women residing in low fertility communities were more likely than women residing in high fertility communities to have a male birth. This finding is consistent with the finding of Jayachandran (2017) which reported that up to half of India’s sex ratio increase during 1981-2011 could be explained by fertility decline. Bhat and Zavier (2003) hypothesized the association between fertility decline and sex bias in terms of parity effect accompanied with the son-preference effect and the technological effect.

While the parity effect and son-preference effect are likely to reduce sex bias when fertility is declining, the technological effect is likely to increase sex bias. Increasing ability of the parents to eliminate children of unwanted sex might intensify sex bias. Bhat and Zavier (2003) showed that technological effect indeed outweighed parity effect and son-preference effect in India in the last two decades.

Our analysis also shows that the regression coefficients presented in the paper are robust to spatial autocorrelation. The analysis suggests that original spatial autocorrelation of SRB is weaker than expected and points to the poor quality of district-level sex ratio estimates in the past studies. The SRBs estimated from survey data might get distorted due to chance. For example, for an observed sex ratio of 107, the 95% confidence interval is 94.5 – 121.2 if the estimation is based on a sample of 1,000 births, 101.2 – 113.1 if based on a sample of 5,000 births, 102.9 – 111.3 if based on a sample of 10,000 births, and 105.7 – 108.3 if based on a sample of 100,000 births, even for samples derived without considering clustering. The confidence intervals are likely to be wider for large-scale sample surveys, which are largely multi-stage cluster samples. Hence, any ecological regression using district-level SRB estimates from survey data are likely to yield biased results. Fortunately, our analysis is based on very large samples thus providing robust estimates of SRB at the national level.

This study has some important limitations. We could not account for genetic factors and under-reporting of female children due to unavailability of data. We also could not include certain variables like women’s work and father’s characteristics due to small sample sizes. In NFHS-4, information on women’s work and father’s characteristics were only collected in 15% of the randomly selected households. We could not capture the cultural practices and norms regarding son preference or daughter aversion, notion and level of patriarchy in different geographical regions of India due to non-availability of data in NFHS-4. We also could not extend our analysis to birth orders 4 or higher, where the effects of independent variables are likely to be strongest, due to small sample sizes. Finally, we were not able to comment upon whether the ultrasound was used for health reasons or for identifying the sex of the baby as such information was not collected in NFHS-4.

Despite these limitations, our analysis provides useful findings that require immediate attention. It appears from the results that sex-selection that was not seen in the *south* in the past is slowly diffusing among the couples in the *south*. It seems that some couples are using ultrasound technology to determine the sex of the fetus and eventually aborting the female fetus. Second, the SRB at birth order 1 is above the normal higher limit which is a matter of great concern. It is unclear whether the observed high SRBs are real or they are because of under-reporting of female births due to reasons unknown to us. Whatever the case may be, future studies should explore the reasons behind high SRB at birth order 1 in India. Third, our analysis indicates that the households holding more than 10 acres of land have considerably higher SRB compared with households not holding land. Even in regressions, households owning more than 10 acres of land were more likely than households not owning land to have a male birth net of other socio-economic, demographic, residence and kinship related variables. Our findings call for more debate around landholding-patriarchy hypothesis to formulate policies and programmes that directly address son-preference and gender-based discrimination. A key strategy to address the landholding-patriarchy hypothesis is the implementation of equal land rights law and restricting the male dominance in ownership and inheritance of land. This strategy is likely to pay higher dividend in the *north, central, and west* India where the SRB is particularly high. These are the geographic regions where even the crop cultivation (particularly wheat) is less female labour intensive. Whereas, female labour is very important in rice cultivating *east* and *south* regions of India. Fourth, we do get evidence for the use of ultrasound technology to detect the sex of the fetus particularly among mothers who do not have a previously surviving son. Although detecting sex of the fetus is banned in India since 1994, our results do indicate that sex-selection is still being carried out though at a smaller scale. Fifth, since the SRB is highly affected by sample size, any ecological analysis of SRBs estimated from survey data must be dealt with caution. Our analysis indeed indicates that spatial autocorrelations of the SRBs at the district level are weaker than those observed in few past studies dealing with sex ratio of children population. Given that the fertility is declining in India and that the sex-selection is spreading to societies that were not known for sex-selection in the past, there is an urgent need for regular monitoring of SRB. The Government of India in the recent past has launched a number of programmes including but not limited to ‘Beti Bachao and Beti Padhao’ to protect girl child from discrimination before and after her birth. Since our sample of births largely relates to period before the launch of these programmes, our study does not provide any indication of the effect of these programmes on improving the health and survival of the girl child.

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Table 1: SRB by various socio-economic, demographic, residence-related, kinship structure-related variables, and use of ultrasound, India

Characteristics	Categories	% distribution of births	Number of births	SRB	95% CI for sex ratio	
					Lower	Upper
Surviving male sibling and order 2 or higher	No	62.0	343286	111.4	110.3	111.7
	Yes	38.0	210174	105.8	104.9	106.5
Ultrasound performed during pregnancy(since 2009)	No	34.9	94128	104.9	103.6	106.3
	Yes	65.1	175717	111.9	110.8	112.9
Household structure	Nuclear household	48.4	267644	107.9	107.1	108.7
	Non-nuclear household	51.6	285817	111.0	110.2	111.8
Presence of an elderly woman (age 60+) in the household	No	78.8	436383	108.8	108.2	109.4
	Yes	21.2	117078	112.3	111.0	113.6
Consanguineous marriage	No	86.6	479201	109.2	108.6	109.8
	Yes	13.4	74260	111.0	109.4	112.6
Child marriage	No	53.1	293387	110.1	109.2	110.8
	Yes	46.9	259635	108.8	108.0	109.6
Mother's schooling	No schooling	36.3	201058	107.5	106.5	108.4
	Primary	14.7	81481	109.6	108.1	111.2
	Secondary	40.6	224723	111.0	110.1	111.9
	Higher	8.3	46198	111.0	109.0	113.0
Mother's age	<20 Years	1.3	7208	106.2	101.4	111.2
	20-29 Years	51.3	283719	108.3	107.5	109.1
	30+ Years	47.4	262535	110.5	109.7	111.4
Difference between ideal number of sons and daughters	=<0	75.2	416023	10.3.3	102.7	103.9
	>0	24.8	137438	130.4	129.0	131.8
Birth order	First	36.3	200959	107.5	106.5	108.4
	Second	30.6	169320	108.3	107.3	109.4
	Third	16.0	88531	115.1	113.5	116.6
	Four or higher	17.1	94651	110.1	108.7	111.5
Wealth index	Poorest	26.5	146656	105.8	104.7	106.9
	Poorer	21.8	120819	107.9	106.7	109.1
	Middle	19.4	107560	111.0	109.7	112.3
	Richer	17.6	97245	110.1	108.7	111.5
	Richest	14.7	81180	116.0	114.4	117.6
Caste	SC	10.6	58635	104.5	102.8	106.2
	ST	21.4	118666	108.3	107.1	109.6
	OBC	44.1	243971	110.1	109.2	111.0
	Other	23.9	132189	111.4	110.2	112.6

Religion	Hindu	78.6	434784	109.6	109.0	110.3
	Muslim	16.5	91481	108.3	106.9	109.7
	Christian	2.1	11528	106.2	102.4	110.1
	Sikh	1.3	7385	116.9	111.7	122.4
	Buddhist/Neo-Buddhist	0.7	4085	114.6	107.8	121.9
	Other	0.8	4198	104.1	98.0	110.6
Place of residence	Urban	28.4	156964	111.4	110.3	112.5
	Rural	71.6	396497	108.8	108.1	109.4
State region	South	17.3	95601	107.5	106.1	108.8
	North	13.9	76915	116.0	114.4	117.6
	Central	27.5	152113	109.2	108.1	110.3
	East	25.1	138799	107.0	105.9	108.2
	North-East	3.7	20676	105.8	102.9	108.7
	West	12.5	69357	111.4	109.8	113.1
Land holding size of the household	No land	58.4	323471	108.8	108.1	109.6
	Up to 10 acres	8.3	45903	109.2	107.2	111.2
	More than 10 acres	16.9	93312	112.3	110.9	113.8
	Land unit not defined	16.4	90774	108.8	107.4	110.2
Average number of children per women at PSU level	>2.8	8.2	45389	103.7	101.8	105.6
	>2.1 & 2.8>=	31.2	172820	108.3	107.3	109.3
	>1.5 & 2.1>=	43.3	239817	110.5	109.6	111.4
	<1.5	17.2	95434	111.9	110.5	113.3
Total			**553461**	**109.2**	**108.6**	**109.8**

Table 2: Results of logistic regression analysis of determinants of having a male birth, based on births between 2005 and 2016, India

Characteristics	Categories	Odds ratio (95% CI)		
		Birth order 1 (1)	Birth order 2 (2)	Birth order 3 or higher (3)
Surviving male sibling and order 2 or higher	Yes®			
	No	NA	1.15 (1.12,1.18)*	1.15 (1.12,1.18)*
Household structure	Nuclear household®			
	Non-nuclear household	1.01 (0.98,1.04)	1.01 (0.98,1.05)	1.00 (0.97,1.03)
Presence of an elderly woman (age 60+) in the household	No®			
	Yes	1.01 (0.98,1.05)	1.03 (0.99,1.07)	1.01 (0.97,1.04)
Consanguineous marriage	No			
	Yes	0.99 (0.95,1.03)	1.06 (1.01,1.11)*	1.04 (1.00,1.08)
Child marriage	No			
	Yes	1.01 (0.98,1.04)	0.97 (0.94,1.00)	1.00 (0.97,1.03)
Mother's schooling	No Education®			
	Primary	1.01 (0.96,1.05)	1.03 (0.99,1.08)	1.04 (1.00,1.08)*
	Secondary	1.03 (0.99,1.07)	1.03 (0.99,1.07)	1.07 (1.04,1.11)*
	Higher	1.01 (0.96,1.07)	1.01 (0.94,1.08)	1.25 (1.13,1.39)*
Mother's age	<20 Years®			
	20-29 Years	0.98 (0.91,1.07)	1.09 (0.89,1.33)	1.37 (0.70,2.70)
	30+ Years	0.96 (0.88,1.06)	1.10 (0.90,1.34)	1.42 (0.72,2.79)
Difference between ideal number of sons and daughters	=<0®			
	>0	1.69 (1.64,1.74)*	1.51 (1.46,1.56)*	1.21 (1.18,1.23)*
Birth order	Four or higher®			
	First	NA	NA	NA
	Second	NA	NA	NA
	Third	NA	NA	1.00 (0.99,1.01)
Wealth index	Poorest®			
	Poorer	1.02 (0.98,1.06)	1.02 (0.98,1.06)	1.02 (0.99,1.05)
	Middle	1.05 (1.01,1.10)*	1.04 (0.99,1.09)	1.04 (1.01,1.09)*
	Richer	1.02 (0.97,1.07)	1.03 (0.97,1.09)	1.10 (1.05,1.16)*
	Richest	1.08 (1.02,1.15)*	1.10 (1.03,1.18)*	1.14 (1.06,1.21)*
Caste	Others®			
	SC	1.02 (0.97,1.07)	0.95 (0.90,0.99)*	0.94 (0.90,0.98)*
	ST	0.99 (0.94,1.04)	0.94 (0.89,1.00)*	0.92 (0.88,0.97)*
	OBC	1.01 (0.98,1.05)	0.96 (0.92,1.00)*	0.97 (0.94,1.00)
Religion	Hindu®			

	Muslim	1.00 (0.96,1.04)	0.96 (0.91,1.00)*	0.96 (0.93,0.99)*
	Christian	0.99 (0.90,1.09)	1.04 (0.94,1.14)	0.98 (0.88,1.08)
	Sikh	0.97 (0.90,1.05)	0.95 (0.87,1.04)	1.13 (1.00,1.28)*
	Buddhist/Neo-Buddhist	1.20 (0.99,1.45)	0.90 (0.75,1.08)	1.11 (0.87,1.41)
	Other	1.05 (0.88,1.26)	1.03 (0.85,1.26)	0.86 (0.74,1.01)
Place of residence	Urban®			
	Rural	0.99 (0.96,1.03)	1.03 (0.99,1.07)	0.99 (0.95,1.03)
State region	South®			
	North	1.02 (0.97,1.07)	1.06 (1.01,1.11)*	1.10 (1.03,1.17)*
	Central	0.92 (0.88,0.96)*	1.02 (0.97,1.07)	1.06 (1.00,1.12)*
	East	0.92 (0.87,0.96)*	1.01 (0.96,1.07)	1.08 (1.02,1.15)*
	North-East	1.01 (0.95,1.06)	0.97 (0.91,1.03)	1.07 (1.00,1.15)*
	West	0.97 (0.91,1.02)	1.04 (0.98,1.11)	1.14 (1.05,1.23)*
Land holding size of the household	No land®			
	Up to 10 acres	0.99 (0.95,1.04)	1.03 (0.98,1.09)	1.01 (0.97,1.06)
	More than 10 acres	0.98 (0.95,1.02)	1.07 (1.03,1.11)*	1.04 (1.01,1.08)*
	Land unit not defined	0.99 (0.96,1.03)	1.00 (0.96,1.04)	0.98 (0.95,1.01)
Average number of children per women at PSU level	>2.8			
	>2.1 & 2.8>=	1.03 (0.97,1.08)	1.06 (1.00,1.11)*	1.06 (1.02,1.09)*
	>1.5 & 2.1>=	1.10 (1.04,1.16)*	1.11 (1.05,1.17)*	1.06 (1.03,1.10)*
	<1.5	1.12 (1.05,1.19)*	1.14 (1.07,1.21)*	1.13 (1.06,1.21)*

Note: NA - Not applicable
*** p< 0.05**
Results adjusted for year of birth
Wealth was associated with the probability of a male birth in *Wald* test

Table 3: Results of logistic regression analysis of determinants of having a male birth for birth order 2 and 3 or higher, based on births in 5 years preceding NFHS-4, India

Characteristics	**Categories**	**Odds ratio (95% CI)**	
		Birth order 2 (1)	**Birth order 3 or more (2)**
Ultrasound performed during pregnancy	No®		
	Yes	0.96 (0.90,1.03)	1.08 (1.03,1.13)*
Surviving male sibling and order 2 or higher	Yes®		
	No	1.06 (1.00,1.12)	1.08 (1.03,1.14)*
Interaction of ultrasound and no surviving male sibling		1.11 (1.03,1.21)*	1.14 (1.05,1.23)*

*** p< 0.05**
Results adjusted for year of birth
All other variables included in Table 2 were controlled in the regressions

Figure 1: Maps showing district SRBs based on births in last one year in 2001 and 2011 Indian Censuses

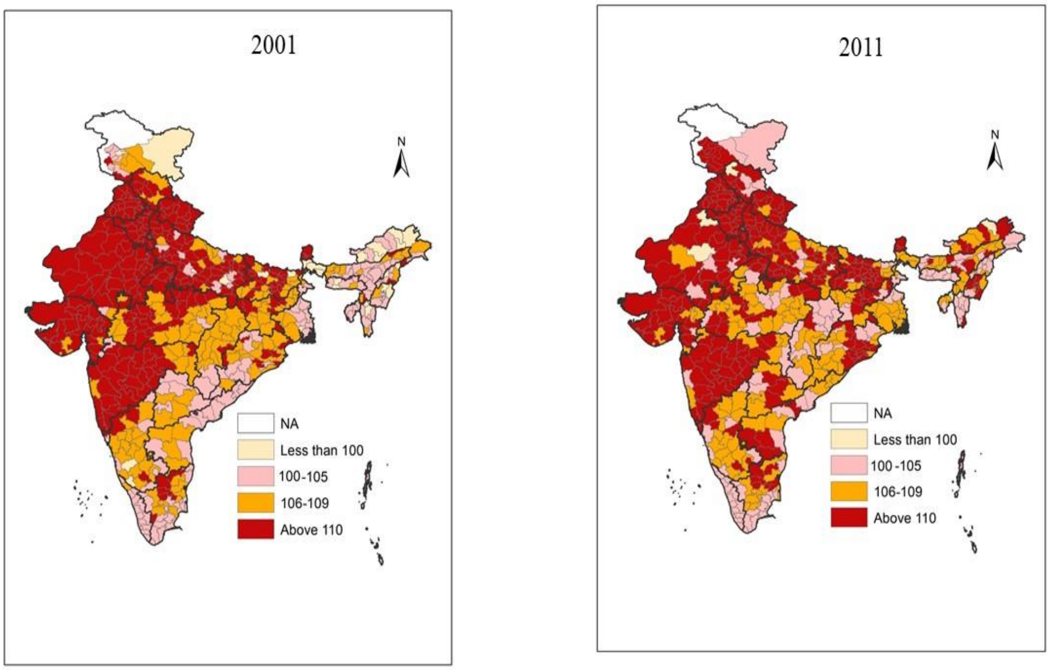

Figure 2: Maps showing spatial distribution of the residuals averaged at the district level, NFHS-4