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Male-Female Disparity in Child Survival in Districts of India

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Abstract

This paper analyses male-female disparity in the probability of survival up to 15 years of age in districts of India. Based on estimates derived from the summary birth history data available from 2011 population census, the paper reveals that in majority of the districts of the country, male-female disparity in survival up to 15 years of age is quite marked in terms of either female survival advantage or male survival advantage. Majority of districts with marked male survival advantage are located in the northern part of the country. There is substantial inequality in male-female disparity in survival up to 15 years of age within district across mutually exclusive population sub-groups. The male-female disparity in survival up to 15 years of age is influenced largely by the male-female survival disparity in 5-9 and 10-14 years of age.

Introduction

District level analyses of child survival in India are rare because district level estimates of the risk of death during childhood are not available either through the civil registration system or the official sample registration system or through surveys like National Family Health Survey. The only source of data to estimate child mortality at the district level is the summary births history (SBH) data available through the decennial population census. These data have been used to estimate the risk of death during childhood at the district level using different indirect techniques of child mortality estimation. (Government of India, 1988; 1997; 2001; Mishra et al, 1994; Rajan et al, 2008; Ahuja, *no date*). In all these studies, the risk of death is estimated for the first five years of the life, although the National Policy for Children, 2013 recognises a person below the age of 18 years as the child (Government of India, 2013). District level estimates of the risk of death in children below 18 years of age are, however, not available. Similarly, truly little is known about within-district residence and social class variation in the risk of death in male and female children. A recent study has analysed excess female under-five mortality in districts of India following a regression residual approach (Guilmoto et al, 2018). This study does not analyse within-district variation in excess female under-five mortality across different social classes and does not consider the male-female disparity in the risk of death beyond five years of age. To the best of our knowledge, there is no study in India which has analysed the male-female disparity in the risk of death in children older than 5 years of age.

In this paper, we analyse male-female disparity in the probability of survival up to 15 years of age in the districts of India. We also analyse how male-female disparity in the probability of survival up to 15 years of age varies across different population sub-groups within the same district. Children below 15 years of age can be grouped into children below 1 year of age; children 1-4 years of age; children 5-9 years of age; and children 10-14 years of age. The rationale for this age grouping of children is grounded in the fact that both probability of survival and male-female disparity in the probability of survival is different in the four age groups as primary causes of death in the four age groups are essentially different. The probability of survival in the first 15 years of life, therefore, is the cumulation of the probability of survival in the four age groups. This means that male-female disparity in survival up to 15 years of age should be analysed in the context of the male-female disparity in survival in the first year of life, in 1-4 years of life, in 5-9 years of life, and in 10-14 years of life.

The paper is organised as follows. The next section of the paper outlines the analytical strategy followed while section three describes the data. The analytical strategy recognises that the probability survival in the first15 years of life varies by both sex and age so that male-female disparity in survival up to 15 years of age is the cumulative effect of male-female survival disparity by age. Inter-district and within-district variation in male-female disparity in survival in the first 15 years of life is discussed in the fourth section of the paper. The fifth section of the paper classifies districts based on the contribution of male-female disparity in survival different age groups to male-female disparity in survival in the first 15 years of life. The last section of the paper summarises main findings of the analysis and discusses their policy and programme implications.

Analytical Framework

The analysis of male-female disparity in survival is essentially an arbitrary procedure (Preston and Weed, 1976). There is no plausible theory or hypothesis about what the male-female disparity in survival in general and child survival in particular should be. Male-female disparity in the risk of death is attributed to both innate biological differences between sexes and social, cultural, and economic determinants of survival (Chaurasia, 1981; United Nations, 2011). The fact that females have two X chromosomes and male one probably confers a survival advantage on females (Naeye et al, 1971). The biological or genetic advantage of females has, however, been argued to be small and largely invariant across populations (Wisser and Vaupel, 2014). On the other hand, females face a range of discrimination in the family and the society because of a host of social, cultural, and economic factors, which may confer a survival disadvantage on them, particularly, after the first year of life. The observed male-female disparity in survival, therefore, is the net of the effect of biological or genetic factors and social, cultural, and economic factors. The relative contribution of biological or genetic factors and social, cultural, and economic factors and the interaction between the two in deciding male-female disparity in survival, however, remains unclear. The relative contribution of biological or genetic factors and social, cultural, and economic factors of male-female disparity in survival varies with age. In the first year of life, female children generally have better survival chances than male children primarily because of biological or genetic factors. However, as age advances, social, cultural, and economic factors, are argued to become more dominant in deciding male-female disparity in survival.

The male-female disparity in survival can be measured in both relative and absolute terms. Historically, male-female disparity in survival has been measured in relative terms as the ratio of male to female probability of survival or, equivalently, the ratio of female to male probability of survival. There are very few studies which have analysed male-female disparity in survival in absolute terms or in terms of the arithmetic difference between male and female probability of survival (Wisser and Vaupel, 2014). However, both relative and absolute differences are influenced by the level of the survival probability (Preston and Weed, 1976; Houweling et al, 2007; Mackenbach, 2015). One problem with relative measures of disparity is that when male to female ratio of the risk of death goes up, the ratio of the reverse outcome (probability of survival) will go down, and vice versa (Scanlan, 2000). This ambiguity of relative measures does not apply to absolute measures. An advantage of measuring male-female disparity in absolute terms is that the arithmetic difference in male-female survival up to a given age can be decomposed into components attributed to male-female disparity in survival in different ages below the given age as the present paper shows.

In view of the hazards of measuring male-female disparity in survival in either relative or absolute terms, an alternative approach involves first establishing an empirically 'normal' relationship between male and female survival probability and then measuring male-female disparity as the deviation from the empirical 'normal' (Preston and Weed, 1976). This approach measures male-female disparity as the difference between the observed male-female disparity and the empirical 'normal.' One approach to establish empirical 'normal' relationship between male and female survival probability is to orthogonal regression, which minimises the sum of squared deviations perpendicular to the line (Preston and Weed, 1976). Orthogonal regression does not require the specification of a 'dependent' variable, a specification that is difficult in case of analysing the relationship between male and female survival probability. The orthogonal regression treats males and females symmetrically. The slope of the orthogonal regression is the geometric mean of the two slopes resulting using least square regression with male survival probability and female survival probability as 'dependent' variable.

The arithmetic difference and the ratio of male-female survival probability can, however, be related using the logarithmic mean of male and female survival probability. If p^m and p^f denote the male and female survival probability, then the logarithmic mean (*LM*) of pm and p^f is defined as (Carlson, 1972; Bhatia, 2008)

$$LM = \frac{p^m - p^f}{ln\left(\frac{p^m}{p^f}\right)} \tag{1}$$

which means that?

$$\frac{p^m}{p^f} = exp\left(\frac{p^m - p^f}{LM}\right) \tag{2}$$

Equation (2) suggests that the arithmetic difference between male-female survival probability up to 15 years of age, ∇, may be written as

$$\nabla = {}_{15}p_0^m - {}_{15}p_0^f = LM * ln\left(\frac{{}_{15}p_0^m}{{}_{15}p_0^f}\right) \quad (3)$$

The probability of survival up to 15 years of age may also be written as

$${}_{15}p_0 = {}_{1}p_0 * {}_{4}p_1 * {}_{5}p_5 * {}_{5}p_{10} \quad (4)$$

so that equation (3) becomes

$$\nabla = LM * \left[ln\left(\frac{{}_{1}p_0^m}{{}_{1}p_0^f}\right) + ln\left(\frac{{}_{4}p_1^m}{{}_{4}p_1^f}\right) + ln\left(\frac{{}_{5}p_5^m}{{}_{5}p_5^f}\right) + ln\left(\frac{{}_{5}p_{10}^m}{{}_{5}p_{10}^f}\right)\right] \quad (5)$$

or

$$\nabla = \partial_1 + \partial_2 + \partial_3 + \partial_4 \quad (6)$$

where

$$\partial_1 = LM * ln\left(\frac{{}_{1}p_0^m}{{}_{1}p_0^f}\right) \quad (7)$$

is the contribution of male-female disparity in the survival probability in the age group 0-1 year to the male-female disparity in the survival up to 15 years of age. Similarly, ∂_2 is the contribution of male-female disparity in the survival probability in the age group 1-4 years; ∂_3 is the contribution of male-female disparity in the survival probability in the age group 5-9 years; and ∂_4 is the contribution of male-female disparity in the survival probability in the age group 10-14 years to male-female disparity in the probability of survival up to 15 years of age.

Equation (6) holds for every population which means that variation in ∇ can be analysed in terms of ∂_1, ∂_2, ∂_3, and ∂_4 through an additive model using the exploratory data analysis technique of mean polish (Selvin, 1996) which is similar to median polish technique with median replaced by mean (Tukey, 1977). Equation (6), when applied to different populations, leads to a two-way table with rows representing populations and columns representing ∂_1, ∂_2, ∂_3, and ∂_4. The mean polish technique then divides the contribution of the male-female disparity in survival probability in an age group in population *j* into four components – a grand mean or average male-female disparity in survival across all populations and all age groups (*g*); average male-female disparity in survival across populations in a given age group *i* ($\bar{a}_i$); average male-female disparity in survival across age groups in population *j* (d^j); and a residual component which is specific to the age group *i* and population *j* (r_{ij}). For example, for population *j*, the contribution of the male-female disparity in survival probability in the age group 0-1 year (∂_1) to male-female disparity in survival up to 15 years of age may be decomposed as

$$\partial_1^j = g + \bar{a}_1 + d^j + r_1^j \quad (8)$$

Similarly,

$$\partial_2^j = g + \bar{a}_2 + d^j + r_2^j \quad (9)$$

$$\partial_3^j = g + \bar{a}_3 + d^j + r_3^j \quad (10)$$

$$\partial_4^j = g + \bar{a}_4 + d^j + r_4^j \tag{11}$$

Since

$$\nabla^j = \partial_1^j + \partial_2^j + \partial_3^j + \partial_4^j \tag{12}$$

It follows that.

$$\nabla^j = \sum_{i=1}^{c} g + \sum_{i=1}^{c} \bar{a}_i + \sum_{i=1}^{c} d^j + \sum_{i=1}^{c} r_i^j \tag{13}$$

Notice that by construction.

$$\sum_{i=1}^{c} \bar{a}_i = 0 \tag{14}$$

$$\sum_{i=1}^{c} r_i^j = 0 \tag{15}$$

So that equation (13) reduces to

$$\nabla^j = c * g + c * \sum_{i=1}^{c} d^j = \nabla_n + \nabla_j \tag{16}$$

Equation (16) suggests that male-female disparity in the probability of survival up to 15 years of age, measured in terms of the arithmetic difference between male-female survival probability comprises of two components. One component is common to all populations (∇_n), while the second component is specific to the population (∇_j). The common component may be perceived as the empirical 'normal' while the specific component (∇_j) is the deviation of the observed male-female disparity in survival up to 15 years of age in population *j* from the empirical 'normal'. It is obvious that $\nabla_j>0$ indicates female disadvantage while $\nabla_j<0$ indicates the male disadvantage in survival up to 15 years of age. When $\nabla_j=0$, male-female disparity in the probability of survival up to 15 years of age in population *j* is equal to the empirical 'normal'. In this paper, we measure male-female disparity in the probability of survival up to 15 years of age in district *j* by ∇_j or the deviation of the observed male-female disparity in the probability of survival up to 15 years of age in district *j* from the empirical 'normal' derived from equation (16). The male-female disparity in survival up to 15 years of age may be termed as marginal female advantage if ($-0.005\leq\nabla_j<0$); moderate female advantage if ($-0.010\leq\nabla_j<-0.005$); and high female advantage if ($\nabla_j<-0.010$). Similarly, male-female disparity in survival may be termed as marginal male advantage if ($0<\nabla_j<0.005$); moderate male advantage if ($0.005\leq\nabla_j<0.010$); and high male advantage if ($\nabla_j\geq0.010$). When $\nabla_j=0$, there is no male-female disparity.

Equation (13) also suggests that empirical 'normal' contribution of male-female disparity in the probability of survival in the age group *i* to the empirical 'normal' male-female disparity in the probability of survival up to 15 years of age is given by.

$$\nabla_{ni} = g + \bar{a}_i \tag{17}$$

Similarly, the contribution of male-female disparity in the probability of survival in the age group *i* to male-female disparity in the probability of survival up to 15 years of age in population *j* may be calculated as

$$\nabla_{ji} = d_i^j + r_i^j \tag{18}$$

Data

The analysis is based on the summary birth history data – number of children ever born and number of children surviving - available through the 2011 population census of India. These data are tabulated by the age of the currently married women in the reproductive age group (15-49 years) for 640 districts of the country as they existed at the time of 2011 population census for the total population and for population sub-groups classified by residence (rural and urban) and social class (Scheduled Castes and Scheduled Tribes). Based on these data, we have estimated the probability of death in the age group less than 1 year; less than 5 years; less than 10 years; and less than 15 years for each of the 640 districts for the total population and for the rural, urban, Scheduled Castes, Scheduled Tribes, and Other Castes population and for 12 mutually exclusive yet exhaustive population subgroups: 1) rural Scheduled Castes male; 2) rural Scheduled Castes female; 3) rural Scheduled Tribes male; 4) rural Scheduled Tribes female; 5) rural Other Castes male; 6) rural Other castes female; 7) urban Scheduled Castes male; 8) urban Scheduled Castes female; 9) urban Scheduled Tribes male; 10) urban Scheduled Tribes female; 11) urban Other Castes male; and 12) urban Other castes female following the indirect technique of child mortality estimation (Maultree et al, 2013). Using these estimates, we have calculated the probability of survival for the 12 mutually exclusive and exhaustive population sub-groups for the age group less than 1 year, 1-4 years, 5-9 years, 10-14 years, and 0-14 years for each of the 640 districts. These estimates constituted the database for the present analysis. Estimates of child survival probability for different population sub-groups could not be calculated for all the 640 districts because there was either no population of some of the population sub-groups in the district or the population of the sub-group was too small to provide reliable estimates of the probability of death and hence the probability of survival in these population sub-groups in the district.

Results

Table 1 and figure 1 present the empirical 'normal' male-female disparity in the probability of survival up to 15 years of age across 640 districts of the country for the total population and for different population sub-groups. In the urban population, the empirical 'normal' female survival advantage is higher than that in the rural population. Among different social classes, the empirical 'normal' female survival advantage is the lowest in Scheduled Tribes but the highest in Other Castes. Similarly, the empirical 'normal' female survival advantage is the lowest in rural Other Castes but the highest in the urban Other Castes. In the rural population, the empirical 'normal' female survival advantage in the Scheduled Castes is higher than that in the Scheduled Tribes but, in the urban areas, the empirical 'normal' female survival advantage in Scheduled Tribes is higher than that in Scheduled Castes. The empirical 'normal female survival advantage is the lowest in the Other Castes in the rural areas, but the highest in the urban areas across the three social classes.

Table 1 and figure 1 also show the contribution of the empirical 'normal' male-female disparity in the probability of survival up to 15 years of age in different age groups to the empirical 'normal' male-female disparity in the probability of survival in the first 15 years of life. The male-female disparity in the probability of survival in the age groups below 1 year, 5-9 years and 10-14 years contributes to the increase in the female survival advantage in the age group 0-14 years but the male-female disparity in the probability of survival in the age group 1-4 years contributes to the decrease, instead increase, in the female survival advantage in the age group 0-14 years. In all the population sub-groups, there is female survival disadvantage or, equivalently, male survival advantage in the age group 1-4 years. Because of the female survival disadvantage in the age group 1-4 years, the female survival advantage in the age group 0-14 years is substantially lower than that determined by the female survival advantage in age groups below 1 year, 5-9 years and 10-14years.

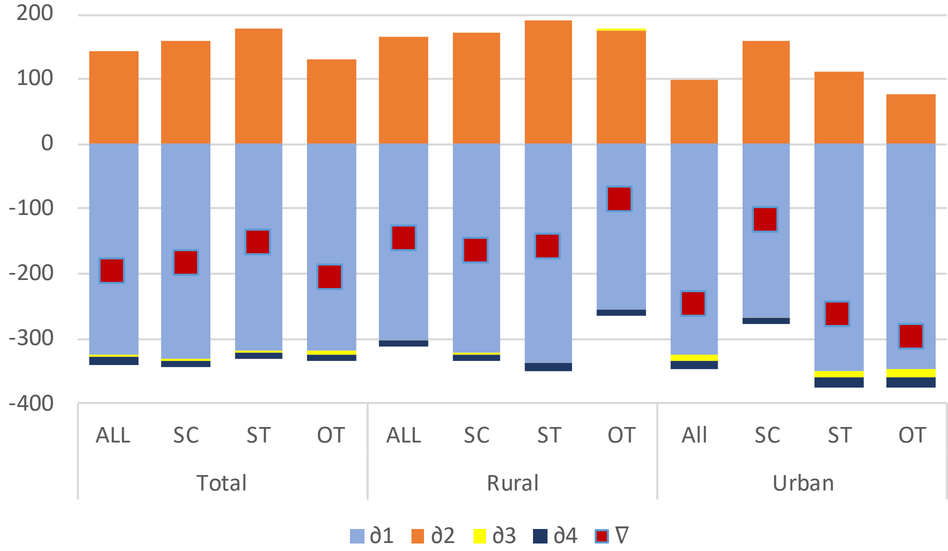

Figure 1: Empirical 'normal' male-female disparity in probability of survival up to 15 years of age (per 100 thousand births) in India and in different population sub-groups.
Source: Author

It may also be seen from table 1 and figure 1 that the empirical 'normal' female survival advantage in the age group 0-14 years is primarily due to the empirical 'normal' female survival advantage in the first year of life, although a substantial proportion of the empirical 'normal' female survival advantage in the first year of life is compromised by empirical 'normal' female survival disadvantage in the age group 1-4 years. Compared to the contribution of the empirical 'normal' male-female disparity in the probability of survival in the first year of life and in the 1-4 years of life to the empirical 'normal' male-female disparity in the probability of survival in the age group 0-14 years, the contribution of the empirical 'normal' male-female disparity in the probability of survival in the age groups 5-9 years and 10-14 years is quite small. The male-female disparity in the probability of survival in the first 15 years of life in the country is determined mainly by the male-female disparity in the probability of survival in the first five years of life. However, the male-female disparity in the probability of survival in the first year of life is favourable to females but the male-female disparity in the probability of survival in 1-4 years of life is favourable to males.

Table 1: Empirical 'normal' male-female disparity (per 100 thousand births) in the survival up to 15 years of age across districts of India.

Population	Male-female disparity	Contribution of male-female disparity the age group				Number of districts
		<1	1-4	5-9	10-14	
	∇	∂_1	∂_2	∂_3	∂_4	
Total	-195	-323	144	-5	-11	640
Scheduled Castes	-184	-331	161	-3	-11	579
Scheduled Tribes	-154	-319	178	-2	-11	556
Other Castes	-205	-317	130	-6	-11	639
Rural	-145	-301	167	-1	-10	631
Scheduled Castes	-164	-322	171	-2	-11	565
Scheduled Tribes	-157	-337	191	-1	-11	540
Other Castes	-86	-257	176	2	-8	630
Urban	-248	-324	98	-10	-12	636
Scheduled Castes	-119	-268	158	0	-9	567
Scheduled Tribes	-262	-349	112	-11	-14	502
Other Castes	-298	-348	77	-13	-14	632

Source: Author's calculations

District level variation in male-female disparity in the probability of survival up to 15 years of age from the empirical 'normal' male-female disparity in the probability of survival in the first five years of life is quite marked as may be seen from table 2. There are 81 (13 per cent) districts where female survival advantage in the age group 0-14 years is high ($\nabla<-0.010$). In these districts, the probability of survival of a female newborn during the first 15 years of life is substantially higher than that of a male newborn. By contrast, in 122 (19 per cent) districts, male survival advantage is high ($\nabla\geq0.010$) which implies that, in these districts, the probability of survival of a female newborn in the first 15 years of life is low than that of a male newborn. On the other hand, there are 139 (22 per cent) districts where the female survival advantage in the first 15 years of life is moderate ($-0.01\leq\nabla<-0.005$). Similarly, there are 109 (17 per cent) districts where the male survival advantage in the first 15 years of life is moderate ($0.005\leq\nabla<0.010$). This leaves 248 (39 per cent) districts in the country where the male-female disparity in survival in the first 15 years of life may be termed as marginal ($-0.005\leq\nabla<0.005$). In 183 (29 per cent) districts, female survival advantage in the first 15 years of life is either moderate or high whereas in 209 (33 per cent) districts male survival advantage in the first 15 years of life is either moderate or high. Out of the 640 districts of the country, the female survival probability in the first 15 years of life is higher than the male survival probability in 322 districts or in around half of the districts. In the remaining 318 (almost 50 per cent) of the districts, the male probability of survival in the first 15 years of life is higher than the female survival probability. In other words, the 640 districts of the country are almost evenly distributed as regards the female advantage or female disadvantage in the probability of survival in the first 15 years of life.

Table 2: Distribution of districts by male-female disparity in the probability of survival in the first 15 years of life by residence and social class.

Male-Female disparity in the probability of survival in the first 15 years of life	Social class			
	All social classes	Scheduled Castes	Scheduled Tribes	Other Castes
	Total population			
High female advantage (∇<-0.010)	81	95	164	108
Moderate female advantage (-0.01≤∇<-0.005)	102	87	59	75
Marginal female advantage (-0.005≤∇<0)	139	103	87	137
Marginal male advantage (-0≤∇<0.005)	109	78	70	110
Moderate male advantage (0.005≤∇<0.010)	87	76	56	81
High male advantage (∇≥0.010)	122	140	120	128
No data	0	61	84	1
	Rural population			
High female advantage (∇<-0.010)	102	123	161	123
Moderate female advantage (-0.01≤∇<-0.005)	94	72	62	94
Marginal female advantage (-0.005≤∇<0)	128	98	84	105
Marginal male advantage (-0≤∇<0.005)	106	62	58	110
Moderate male advantage (0.005≤∇<0.010)	81	71	56	61
High male advantage (∇≥0.010)	120	139	119	137
No data	9	75	100	10
	Urban population			
High female advantage (∇<-0.010)	102	132	192	109
Moderate female advantage (-0.01≤∇<-0.005)	68	68	34	64
Marginal female advantage (-0.005≤∇<0)	120	64	38	112
Marginal male advantage (-0≤∇<0.005)	140	67	39	131
Moderate male advantage (0.005≤∇<0.010)	73	55	46	71
High male advantage (∇≥0.010)	133	181	153	145
No data	4	73	138	8

Source: Author's calculations

The proportion of districts having either substantial female survival advantage or substantial male survival advantage in the first 15 years of life varies across different population sub-groups. In the rural population, 196 (31 per cent) districts have substantial female survival advantage in the first 15 years of life while 201 (32 per cent) districts have substantial male survival advantage in the first 15 years of life so that in 234 (37 per cent) districts of the country, either female or male survival advantage is, at best, marginal (Table 2). The corresponding proportions in the urban population are 27 per cent, 32 per cent and 41 per cent, respectively. Similarly, the proportion of districts having substantial female survival advantage in the first 15 years of life is the highest in Scheduled Tribes while the proportion of districts having substantial male survival advantage in the first 15 years of life is the highest in Scheduled Castes. On the other hand, the proportion of districts having marginal male-female disparity in the probability in the first 15 years of life is the highest in Other Castes. Among the six mutually exclusive population sub-groups, the proportion of districts having substantial female survival advantage in the first 15 years of life is the highest in Urban Scheduled Tribes while the proportion of districts having substantial male survival advantage in the first 15 years of life is the highest in urban Scheduled Castes. On the other hand, the proportion of districts where male-female disparity in the probability of survival in the first 15 years of life is the highest in urban Other Castes. Table 2 also suggests that the inter-district variation in the male-female disparity in the probability of survival in the first 15 years of life in India is determined by the within-district variation in male-female disparity across the six mutually exclusive population sub-groups. It may, however, be noted that the rural-urban distribution and the social class composition of the population is different in different districts of the country and these variations also have an impact on the inter-district variation in male-female disparity in the probability of survival up to 15 years of age.

Districts according to the male-female disparity in survival up to 15 years of age are not distributed uniformly across different states and Union Territories of the country. There is a clear north-south divide in the male-female disparity in survival up to 15 years of age in the total population and in all population sub-groups as may be seen from figures 2 through 13. In the northern part of the country, male advantage in survival up to 15 years of age appears to be the norm in all population sub-groups. Majority of the districts having male survival advantage or female survival disadvantage in the first 15 years of life are located in the northern part of the country (Figure 2). On the other hand, the situation appears to be mixed in the southern part of the country where there is female survival advantage in majority of the districts. At the same time, the magnitude of male-female disparity in survival up to 15 years of age is marginal in a substantial proportion of districts of this region while there is only a small proportion of districts where male advantage in survival is substantial. There are six states/Union Territories – Delhi, Uttar Pradesh, Bihar, and Nagaland – where there is no district where female survival advantage in the first 15 years of life is either high or moderate. On the other hand, there is no district in Himachal Pradesh, West Bengal, Chhattisgarh, Andhra Pradesh, and Kerala where the male survival advantage in the first 15 years of life is either moderate or high. In West Bengal, the male-female disparity in survival up to 15 years of age is marginal in 16 of the 19 districts or in more than 84 per cent districts of the state. In Punjab, Haryana, Nagaland, Maharashtra, Andhra Pradesh, and Kerala also, the male-female disparity in the probability of survival up to 15 years of age is found to be marginal in more than 60 per cent of the districts (Table 3).

The male-female disparity in survival up to 15 years of age is also found to vary across the six mutually exclusive population sub-groups in each district. There are only 42 (6.6 per cent) districts in the country where female children have a survival advantage over male children in all the six mutually exclusive population sub-groups (Figure 14). Similarly, there are only 61 (9.5 per cent) districts in the country where male children have a survival advantage over female children in all the six mutually exclusive population sub-groups. In the remaining districts of the country, the survival advantage of either female or male children over male or female children in one or more mutually exclusive population sub-groups is associated with the survival disadvantage of either female or male children over male or female children in other population sub-groups. This indicates that, even within a district, the factors that determine the male-female disparity in survival up to first 15 years of life are different for different population sub-groups.

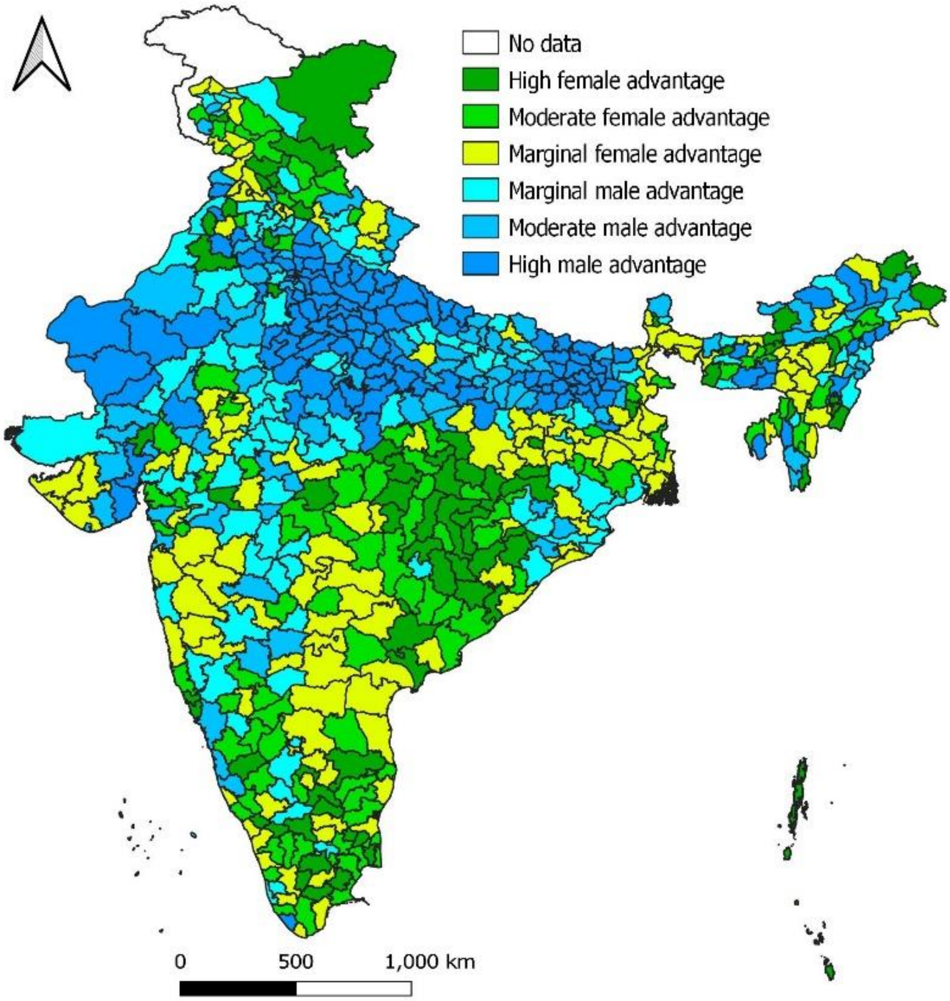

Figure 2: Inter-district variation in male-female disparity in child survival - total population.
Source: Author

Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

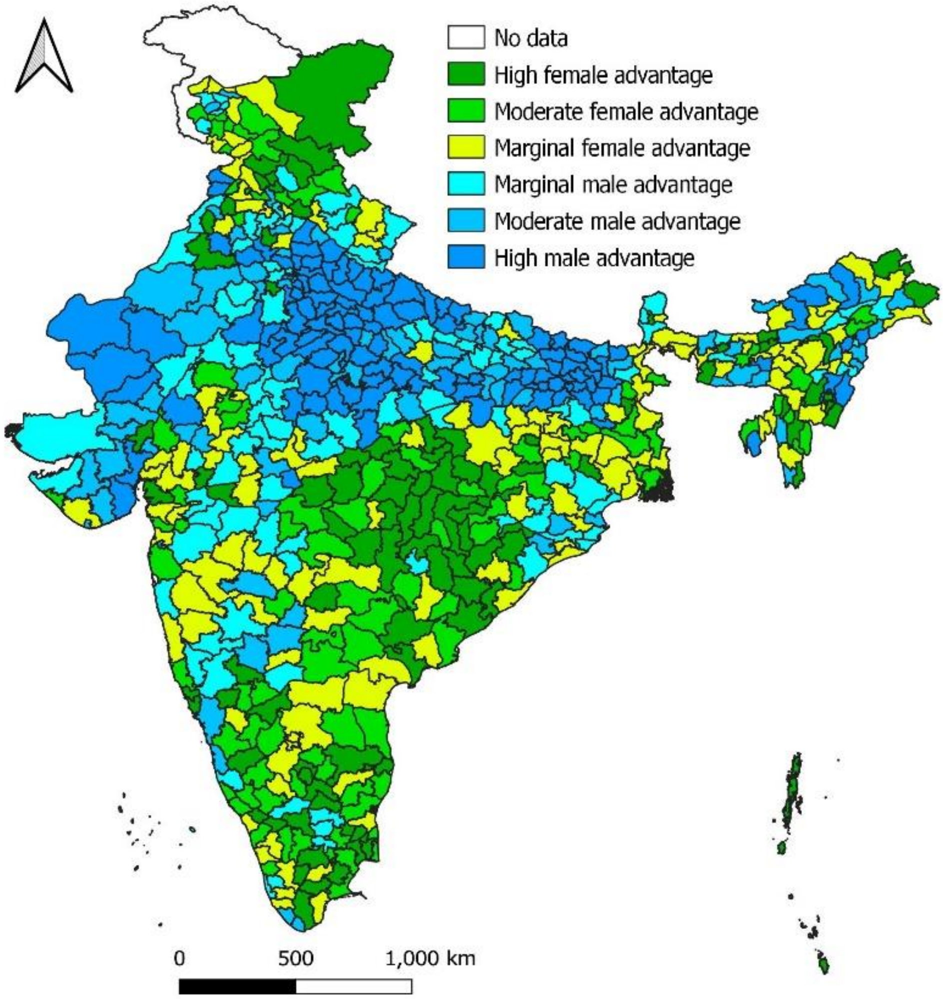

Figure 3: Inter-district variation in male-female disparity in child survival - rural population.
Source: Author
Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

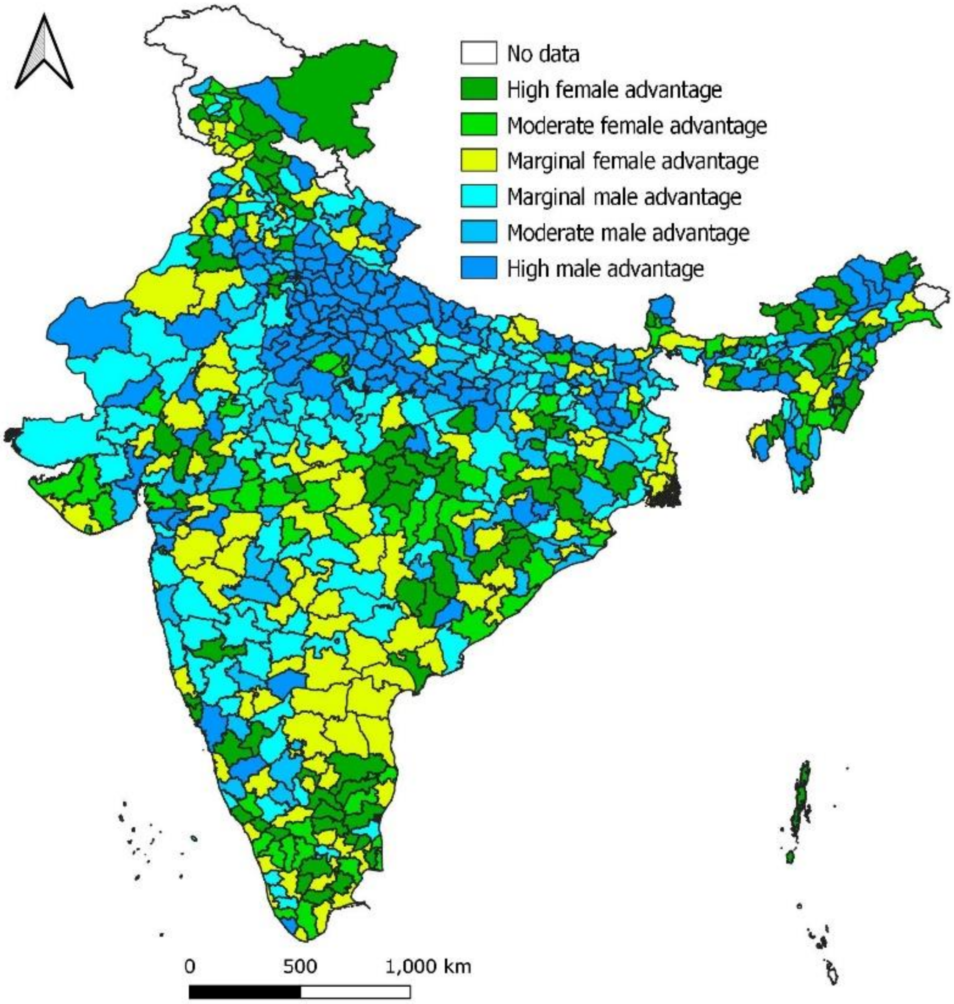

Figure 4: Inter-district variation in male-female disparity in child survival - urban population.
Source: Author
Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

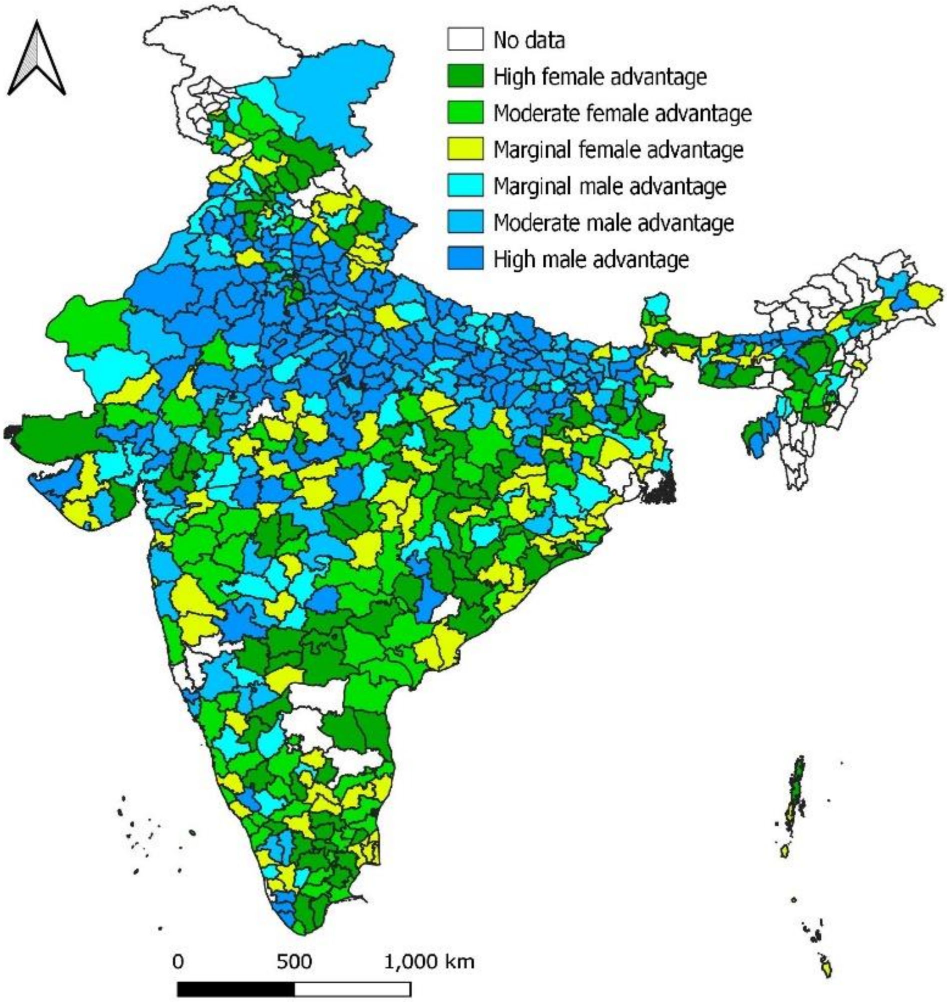

Figure 5: Inter-district variation in male-female disparity in child survival - Scheduled Castes total.

Source: Author

Remarks:
High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

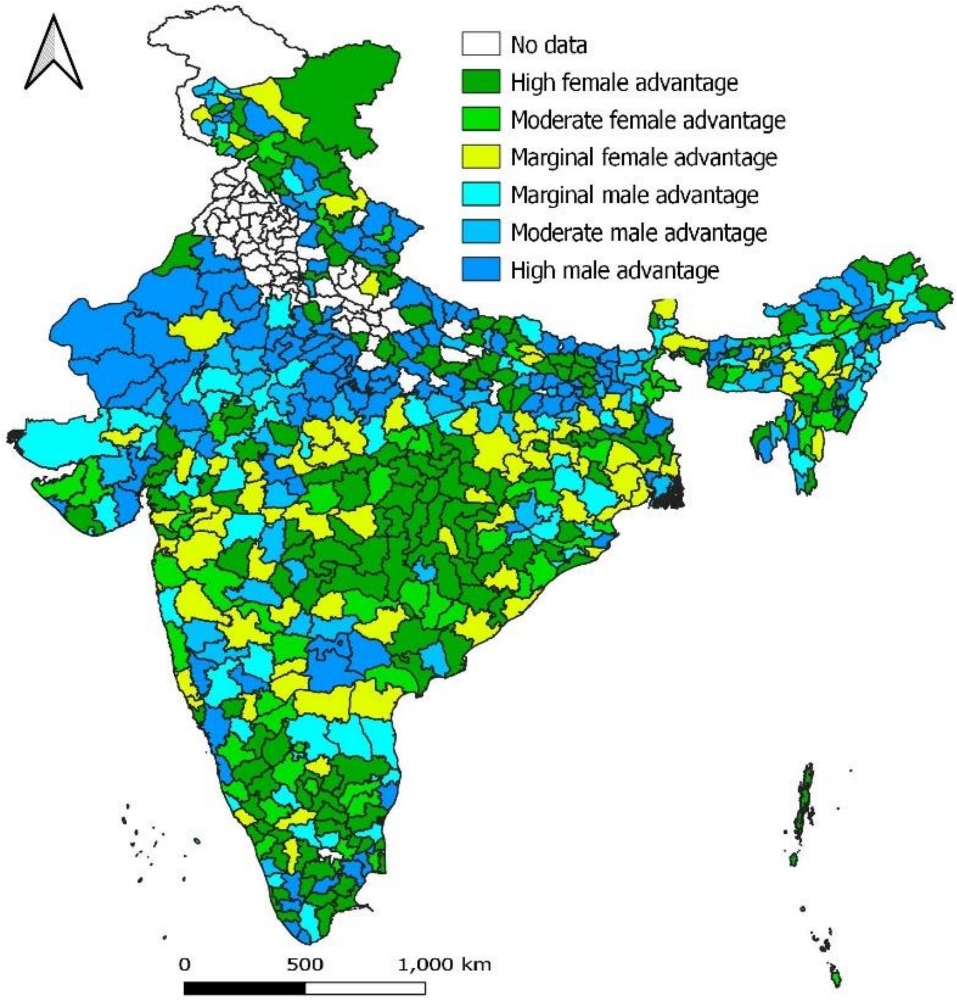

Figure 6: Inter-district variation in male-female disparity in child survival - Scheduled Tribes total.

Source: Author

Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

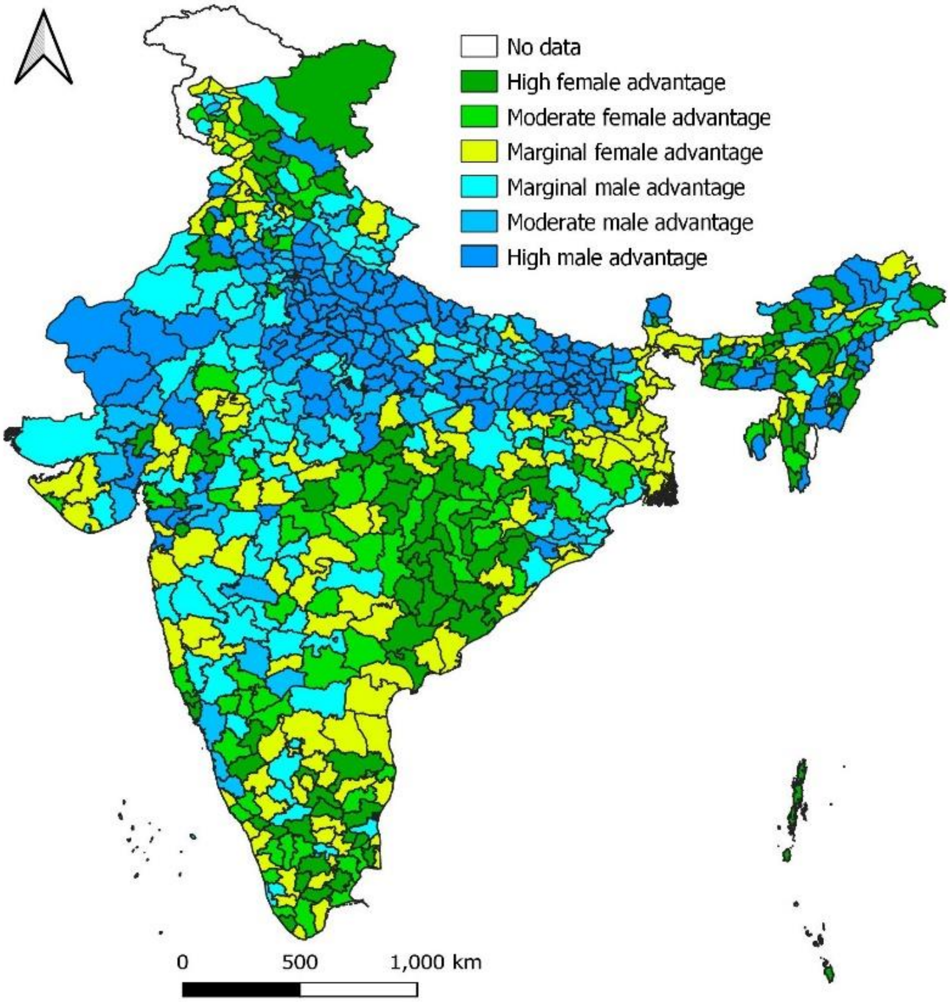

Figure 7: Inter-district variation in male-female disparity in child survival - Other Castes total.

Source: Author

Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

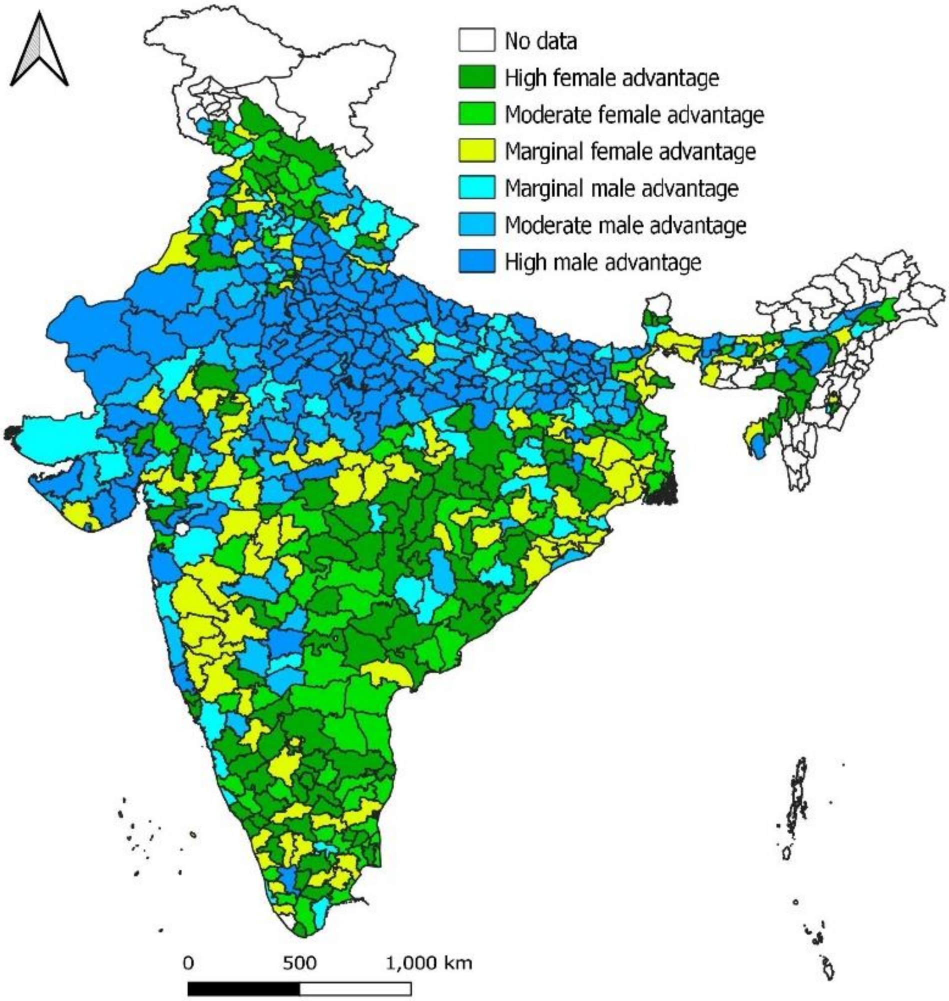

Figure 8: Inter-district variation in male-female disparity in child survival - Scheduled Castes rural.

Source: Author

Remarks: High female advantage ($\nabla<-0.010$)
Moderate female advantage ($-0.01\leq\nabla<-0.005$)
Marginal female advantage ($-0.005\leq\nabla<0$)
Marginal male advantage ($-0\leq\nabla<0.005$)
Moderate male advantage ($0.005\leq\nabla<0.010$)
High male advantage ($\nabla\geq0.010$)

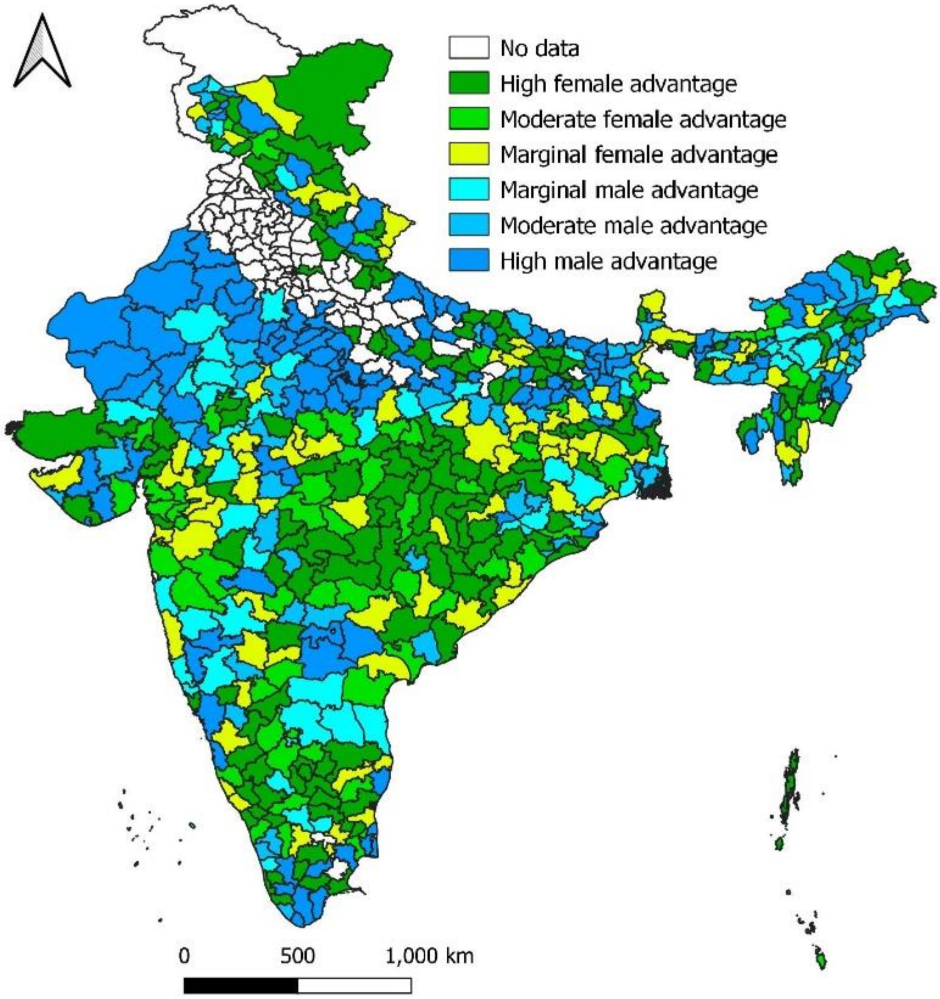

Figure 9: Inter-district variation in male-female disparity in child survival - Scheduled Tribes rural.

Source: Author

Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

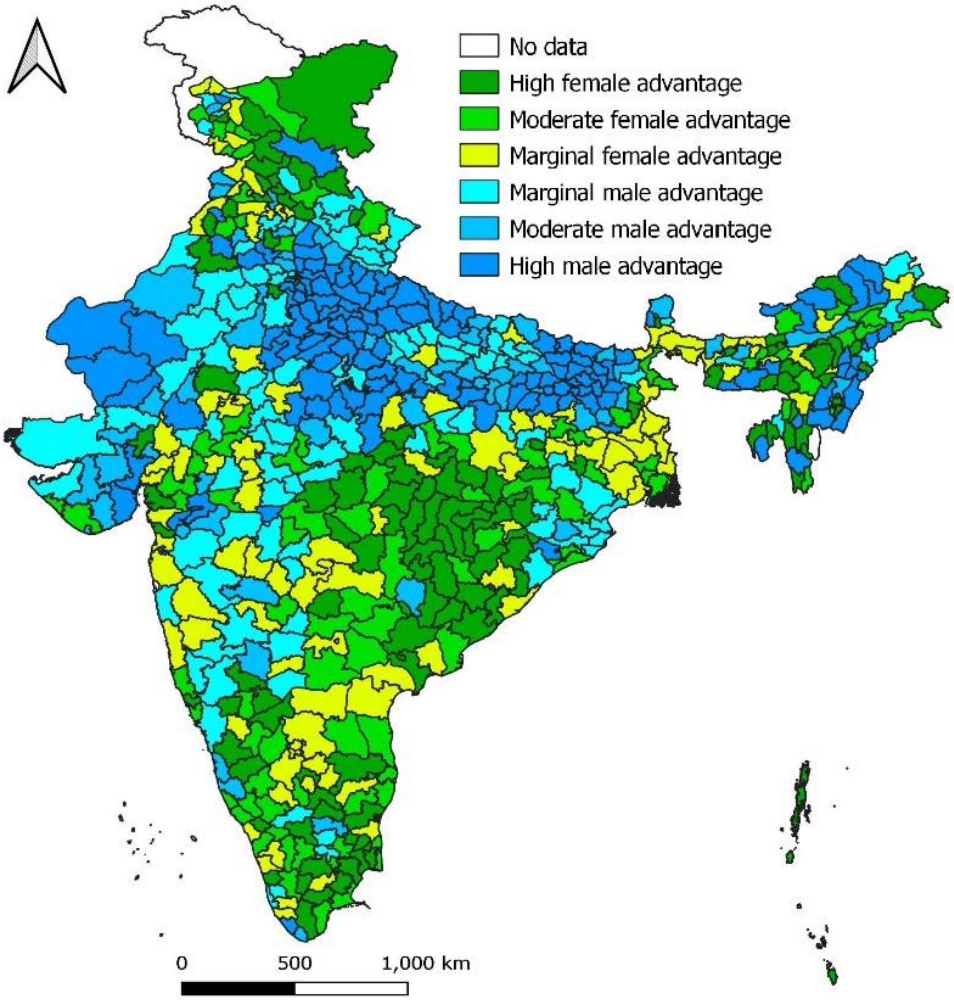

Figure 10: Inter-district variation in male-female disparity in child survival - Other Castes rural.

Source: Author

Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

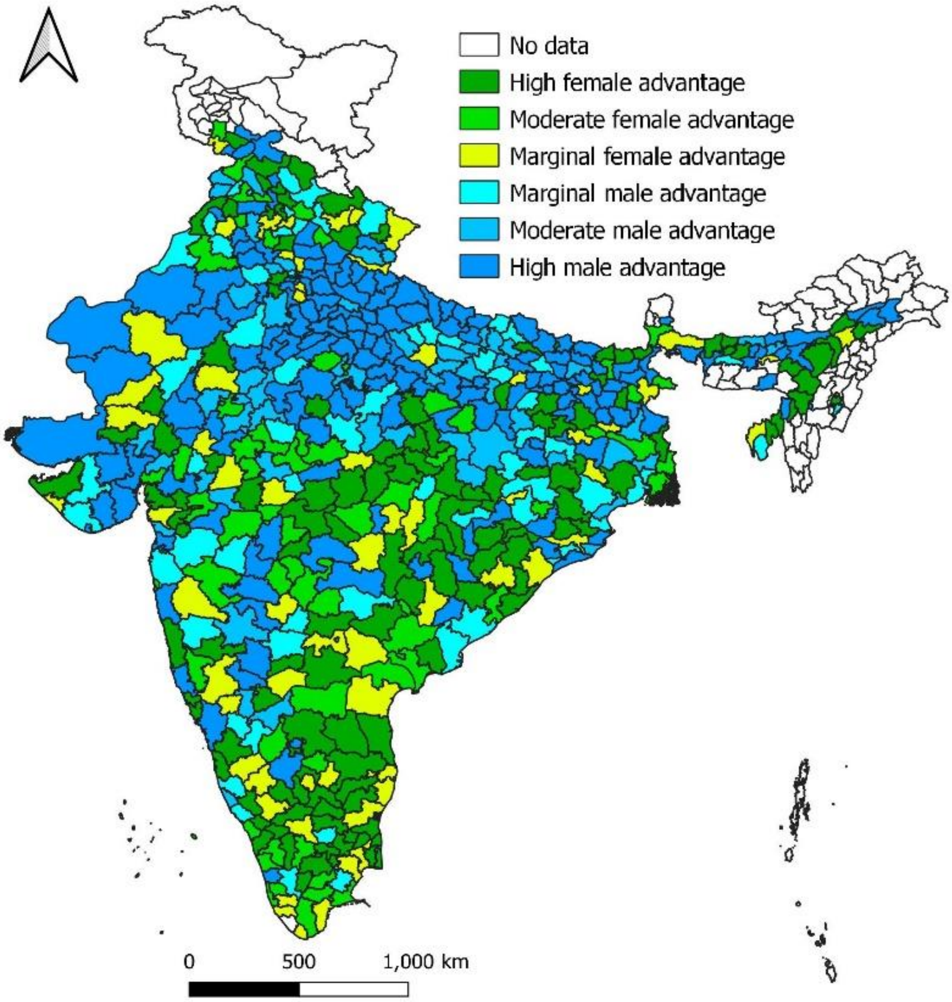

Figure 11: Inter-district variation in male-female disparity in child survival - Scheduled Castes urban.
Source: Author
Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

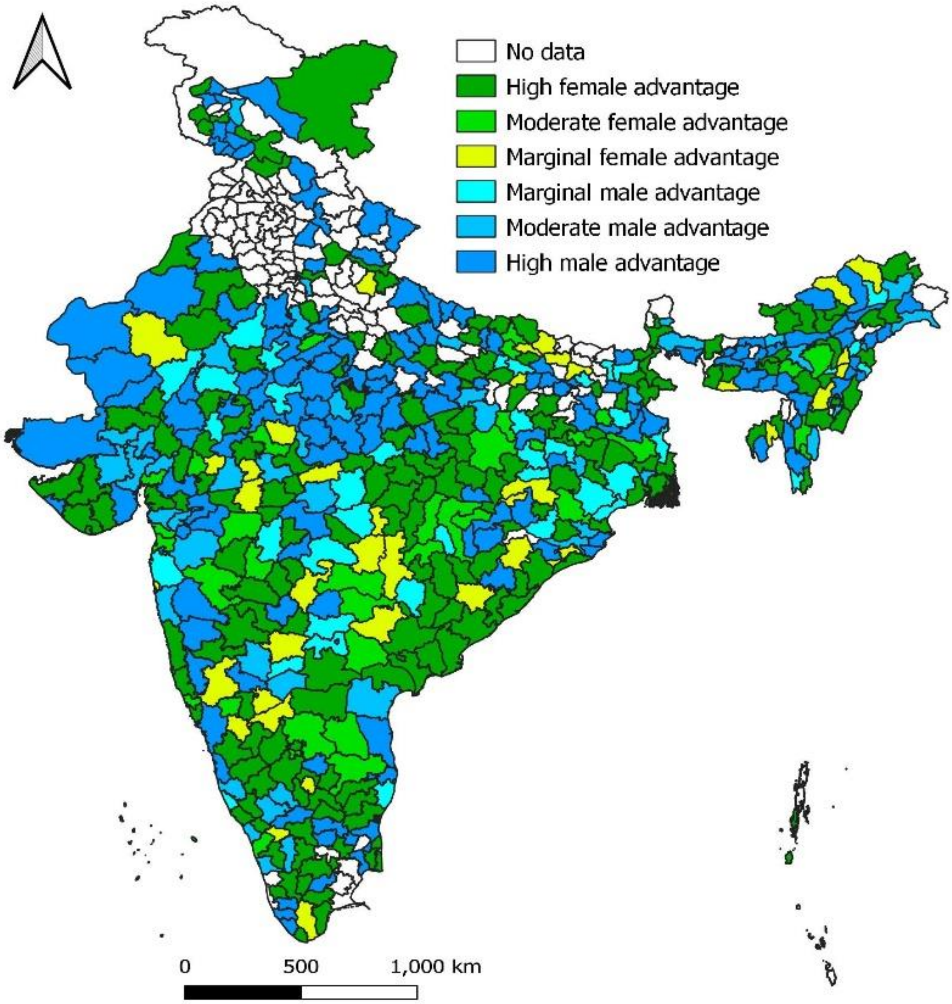

Figure 12: Inter-district variation in male-female disparity in child survival - Scheduled Tribes urban.

Source: Author

Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

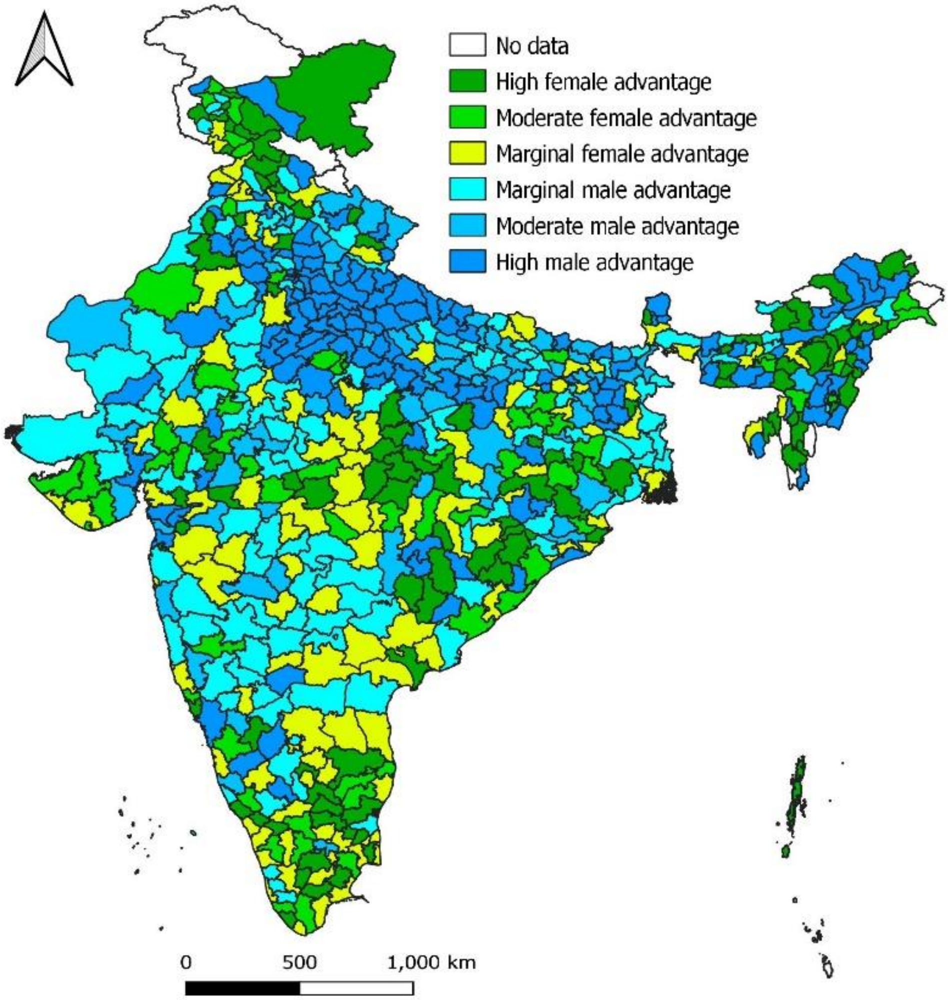

Figure 13: Inter-district variation in male-female disparity in child survival - Other Castes urban.

Source: Author

Remarks: High female advantage (∇<-0.010)
Moderate female advantage (-0.01≤∇<-0.005)
Marginal female advantage (-0.005≤∇<0)
Marginal male advantage (-0≤∇<0.005)
Moderate male advantage (0.005≤∇<0.010)
High male advantage (∇≥0.010)

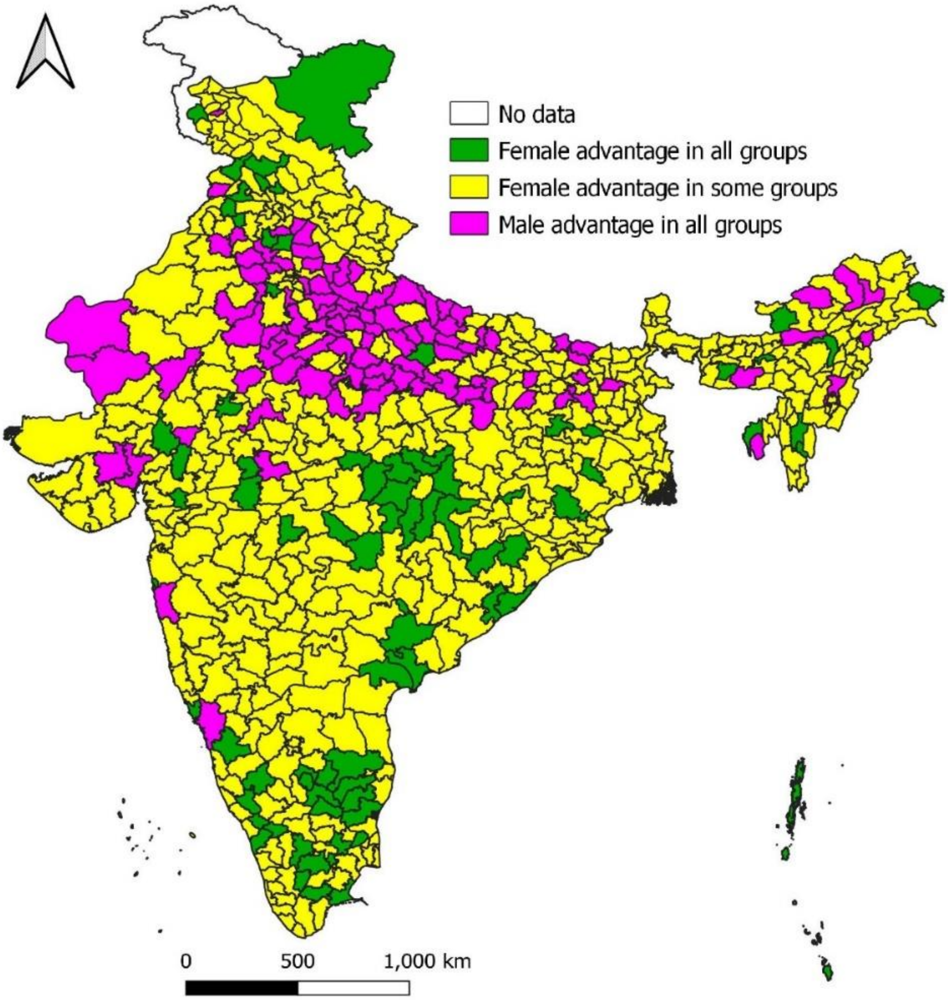

Figure 14: Within-district male-female disparity in survival up to 15 years of age.
Source: Author

Table 3: Distribution of districts by male-female disparity in the probability of survival up to 15 years of age across states/Union Territories.

Country/State/ Union Territory	Male-female disparity in survival in 0-14 years of age						Number of districts
	Female advantage			Male advantage			
	High	Moderate	Marginal	Marginal	Moderate	High	
Andaman & Nicobar Islands	3	0	0	0	0	0	3
Andhra Pradesh	4	5	13	1	0	0	23
Arunachal Pradesh	3	0	4	1	4	4	16
Assam	5	6	8	4	3	1	27
Bihar	0	0	1	3	7	27	38
Chandigarh	0	1	0	0	0	0	1
Chhattisgarh	8	7	2	1	0	0	18
Dadra & Nagar Haveli	0	0	1	0	0	0	1
Daman & Diu	0	1	1	0	0	0	2
Delhi	0	0	0	3	2	4	9
Goa	2	0	0	0	0	0	2
Gujarat	1	5	7	4	7	2	26
Haryana	2	1	1	3	7	7	21
Himachal Pradesh	6	5	0	1	0	0	12
Jammu & Kashmir	2	6	7	5	2	0	22
Jharkhand	3	4	9	5	2	1	24
Karnataka	2	10	6	7	5	0	30
Kerala	1	4	6	3	0	0	14
Lakshadweep	0	0	0	0	0	1	1
Madhya Pradesh	6	9	8	11	8	8	50
Maharashtra	1	8	14	10	2	0	35
Manipur	4	1	2	1	0	1	9
Meghalaya	1	1	1	1	0	3	7

Country/State/ Union Territory	Male-female disparity in survival in 0-14 years of age						Number of districts
	Female advantage			Male advantage			
	High	Moderate	Marginal	Marginal	Moderate	High	
Mizoram	1	2	1	1	2	1	8
Nagaland	0	0	2	5	2	2	11
Odisha	7	5	6	9	3	0	30
Puducherry	4	0	0	0	0	0	4
Punjab	2	1	7	5	2	3	20
Rajasthan	1	1	2	11	7	11	33
Sikkim	1	0	1	1	1	0	4
Tamil Nadu	11	13	7	1	0	0	32
Tripura	0	2	1	0	0	1	4
Uttar Pradesh	0	0	2	7	17	45	71
Uttarakhand	0	1	4	4	4	0	13
West Bengal	0	3	15	1	0	0	19
India	81	102	139	109	87	122	640

Source: Author’s calculations

The male-female disparity in the probability of survival up to 15 years of age is the cumulation of the male-female disparity in the probability of survival in age groups below 1 year; 1-4 years; 5-9 years; and 10-14 years. We have carried out a classification modelling exercise using the classification and regression tree (CRT) technique to classify districts by the male-female disparity in the probability of survival up to 15 years of age in terms of the contribution of male-female disparity in survival probability in age groups below 1 year; 1-4 years; 5-9 years; and 10-14 years to the male-female disparity in survival probability in 0-14 years of age. Districts were classified into six categories for the purpose of classification modelling exercise: 1) districts having high female survival advantage; 2) districts having moderate female survival advantage; 3) districts having marginal female survival advantage; 4) districts having marginal male survival advantage; 5) districts having moderate male survival advantage; and 6) districts having high male survival advantage. The independent variables included contribution of male-female disparity in survival in the first year of life; in 1-4 years of life; in 5-9 years of life; and in 10-14 years of life to the male-female disparity in survival in the first 15 years of life. Results of the classification modelling exercise are presented in table 4 and the associated classification tree is depicted in Figure 15.

The classification modelling exercise suggests that 640 districts of the country can be grouped into 6 mutually exclusive, yet exhaustive groups or clusters of districts based on the contribution of male-female disparity in survival in the age groups 5-9 years and 10-14 years and the male-female disparity in survival up to 15 years of age in different groups of districts identified through classification modelling exercise is different. The first group or cluster comprises of 80 districts and all districts of this cluster have high female survival advantage in the first 15 years of life. The high female survival advantage in districts of this cluster is mainly because of the high female survival advantage in the age group 10-14, although a part of this advantage is compensated by male survival advantage in the age group 5-9 years. The second cluster or group of districts comprises of 109 districts out of which 102 districts have moderate female survival advantage, 1 district has high female survival advantage and 6 districts have marginal female survival advantage. The female survival advantage in these districts is also due to the female survival advantage in the age group 10-14 years as the survival advantage is favourable t males in the age group 5-9 years. The third cluster comprises of 134 districts and in 131 districts of this cluster, the probability of survival during the first 15 years of life is marginally favourable to females because of the female survival advantage in the age group 10-14 years. The survival probability in the age group 5-9 years continues to be unfavourable to females in districts of this cluster also. The fourth cluster of districts has 105 districts and 103 districts of this cluster have marginal male survival advantage while 2 districts have marginal female survival advantage. The distinguishing feature of the districts of this cluster is that the probability of survival in the age group 5-9 years is favourable to males. The fifth cluster of districts has 89 districts and all, but 3 districts of this cluster have moderate male survival advantage while 3 have marginal male survival advantage. The male survival advantage in the first 15 years of life in districts of this cluster is mainly because of substantial male survival advantage in the age group 5-9 years. Finally, the sixth and the last cluster has 123 districts and all, but 1 district of this cluster have high male survival advantage while one district has moderate male survival advantage in the first 15 years of life mainly because of high male survival advantage in 5-9 years of age.

Table 4: Results of the classification of districts in terms of male-female disparity in survival up to 15 years of age per 1000 live births by the contribution of male-female disparity in survival in age groups 0-1 year, 1-4 years, 5-9 years, and 10-14 years

Node ID	Contribution of male-female disparity in survival in the age group per 1000 live births				Male-female disparity in survival in the age group 0-14 years per 1000 live births						Total
					Female advantage			Male advantage			
	0-1	1-4	5-9	10-14	High	Moderate	Marginal	Marginal	Moderate	High	
9	All	All	≤0.005	≤-0.300	80	0	0	0	0	0	80
10	All	All	≤0.005	>-0.300 ≤-0.135	1	102	6	0	0	0	109
6	All	All	≤0.005	>-0.135	0	0	131	3	0	0	134
7	All	All	>0.005 ≤0.315	All	0	0	2	103	0	0	105
8	All	All	>0.315 ≤0.665	All	0	0	0	3	86	0	89
2	All	All	>0.665	All	0	0	0	0	1	122	123
All	All	All	All	All	81	102	139	109	87	122	640

Source: Author's calculations

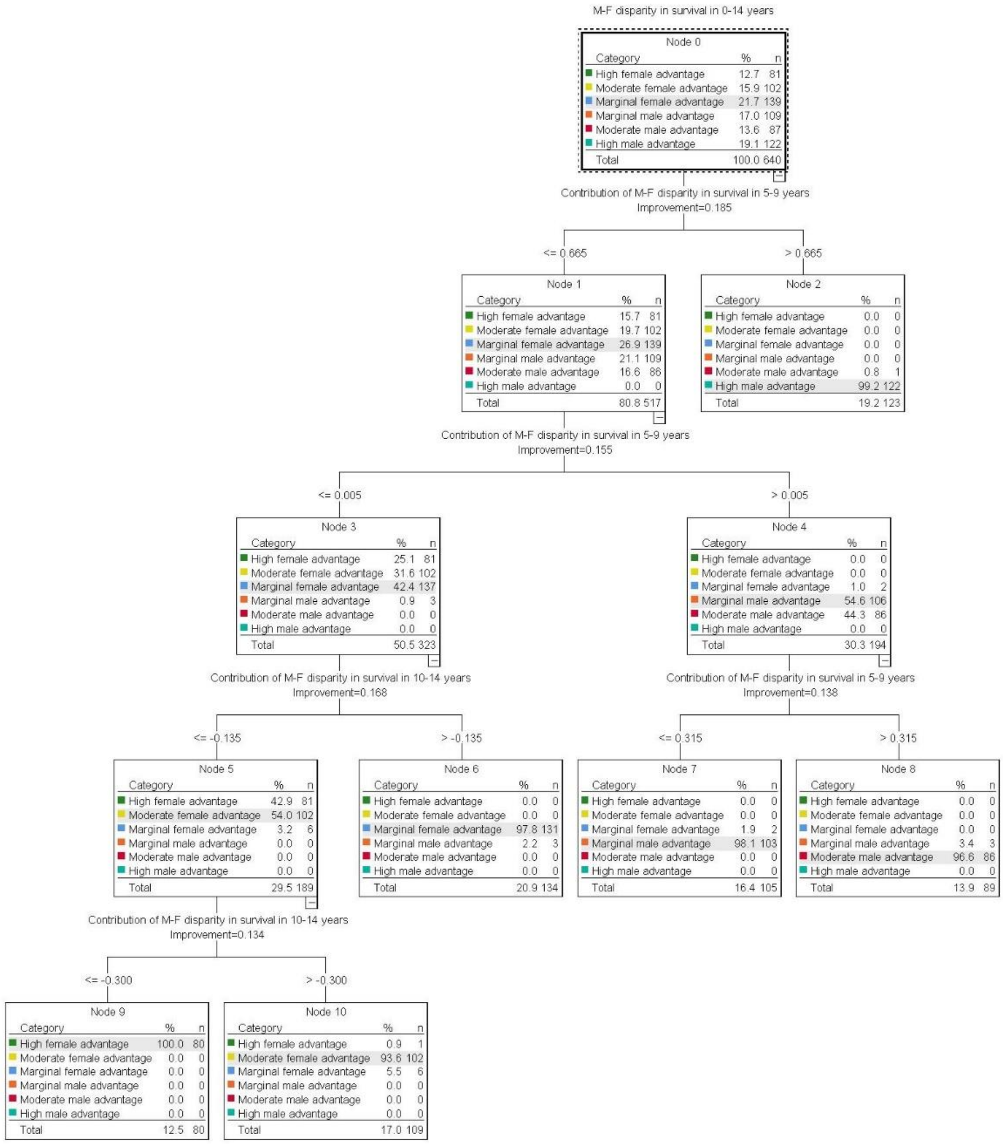

Figure 15: Classification of districts by male-female (M-F) disparity in survival (per 1000 live births) in 0-14 years of age by the contribution of M-F disparity in survival (per 1000 live births) in age groups 0-1 year, 1-4 years, 5-9 years, and 10-14 years.
Source: Author

The accuracy of the classification modelling exercise in classifying a district by male-female disparity in survival up to 15 years of age is found to be 97.5 per cent. There are only 16 districts where classification based on the model differed from the actual observation which shows that the classification modelling exercise has served the purpose. The most important classification variable is found to be the contribution of the male-female disparity in the probability of survival in the age group 10-14 years, closely followed by the male-female disparity in the probability of survival in the age group 5-9 years. The importance of the male-female disparity in survival in the age group 1-4 years in deciding the male-female disparity in the probability of survival up to 15 years of age has been found to be the lowest among the four independent variables used in the classification modelling exercise. The analysis also reveals that the contribution of male-female disparity in survival in the first year of life and male-female disparity in the probability of survival in 1-4 years of life to the male-female disparity in the probability of survival in the 15 years of age across the districts. The male-female disparity in the probability of survival up to 15 years of age is determined largely by the male female disparity in the probability of survival in the age groups 5-9 years and 10-14 years. The contribution of the variation in male-female disparity in the probability of survival in either first of life or in 1-4 years of life to the variation in the probability of survival in the first 15 years of life is not significant.

The classification modelling exercise highlights the importance of male-female disparity in survival in the age groups 5-9 years and 10-14 years in deciding the male-female disparity in survival in the age group 0-14 years across the districts of the country. Male-female disparity in survival in the age groups 0-1 year and 1-4 years also matters in determining the male-female disparity in survival in the age group 0-14 years but the contribution of the male-female disparity in survival in 0-1 year and 1-4 years of age in deciding the male-female disparity in 0-14 years of age is not as important as the contribution of male-female disparity in survival in the age groups 5-9 years and 10-14 years. This observation bears significance at the policy and programme level as the strategy and the interventions required for addressing male-female disparity in survival in age groups 5-9 years and 10-14 years are different from the strategy and interventions required for addressing male-female disparity in survival in age groups 0-1 year and 1-4 years.

Discussions and Conclusions

This paper follows a non-parametric approach to establish empirical 'normal' male-female disparity in the probability of survival in the first 15 years of life across the districts of India. Based on district level estimates of the risk of death in the first 15 years of life derived from the summary birth history data from the 2011 population census, our analysis suggests that the empirical 'normal' male-female disparity in child survival up to 15 years of age in the country is marginally favourable to female in the total population and in the six mutually exclusive yet exhaustive population sub-groups. Deviations from this empirical 'normal' across the districts are substantial and in more than 60 per cent districts of the country, the male-female disparity in the probability of survival up to 15 years of age is quite marked. The analysis also reveals that districts having marked male survival advantage or marked female survival disadvantage are mostly located in the northern part of the country.

In some states and Union Territories, there is not a single district with female survival advantage up to 15 years of age. Similarly, in some states and Union Territories, there is not a single district with male survival advantage. The analysis also reveals that there is substantial male-female disparity in the probability of survival in the first 15 years of life within district across the 6 mutually exclusive and exhaustive population sub-groups characterised by the residence and social class. There are very few districts in the country where there is female survival advantage in all the 6 mutually exclusive and exhaustive population sub-groups in the district. Similarly, there are very few districts where there is male survival advantage in all the 6 mutually exclusive and exhaustive population sub-groups. In most of the districts of the country, female survival advantage or male survival disadvantage in 0-15 years of age in some population sub-groups is found to be associated with female survival disadvantage or male survival advantage in other population sub-groups. Moreover, the classification modelling exercise suggests that inter-district variation in the male-female disparity in the probability of survival in age groups 5-9 years and 10-14 years largely determines the inter-district variation in male-female disparity in the probability of survival in the age group 0-14 years.

The findings of the present analysis have important policy and programme implications. Although, the male-female disparity in child survival varies widely across the districts of the country yet there are districts where this disparity is quite marked either in favour of females or in favour of males. This means that a district-based approach is needed to address the male-female disparity in child survival in these districts. A high female advantage in child survival may be due to low probability of survival of male children from the empirical 'normal.' Similarly, high male advantage in child survival may be due to exceptionally low probability of survival of female children from the empirical 'normal. There is a need to examine the district-specific factors that may be responsible for the male-female disparity in child survival in the district.

The analysis has also revealed that there is substantial male-female disparity in child survival within the district across mutually exclusive population sub-groups classified by residence and social class. This means that the male-female disparity in child survival is also influenced by the residence and social class composition of the population. Reduction in the within-district variation in male-female disparity in child survival across population sub-groups classified by residence and social class may contribute to the reduction in male-female disparity in child survival in the district. Planning and programming for improving child survival at the district should, therefore, be directed towards reducing the variation in the male-female disparity in child survival across different population sub-groups within the same district by evolving and adopting different strategy of addressing male-female disparity in child survival in different population sub-groups. This is important as the present analysis has revealed that there are only a few districts in the country where the direction of the male-female disparity in child survival is the same in all the population sub-groups within the district classified by residence and social class and the composition of population by residence and social class is different in different districts. Lastly, planning and programming for reducing male-female disparity in child survival should also give particular attention to male-female disparity in survival in children older than 5 years of age as male-female disparity in survival in these children varies widely across the districts of the country.

References

Ahuja S (*no date*) Indirect estimates of district wise IMR and under 5 mortality using census 2011 data – draft. New Delhi, National Health System Resource Centre.

Bhatia R (2008) The logarithmic mean. *Resonance*, June 2008: 583-594.

Carlson BC (1972) The logarithmic mean. *American Mathematical Monthly* 79: 615–618.

Chaurasia AR (1981) Sex Mortality Differentials in Developing Countries. PhD Dissertation. Gwalior, Jiwaji University.

Government of India (1988) *Census of India 1981. Child Mortality Estimates of India*. New Delhi, Office of the Registrar General. Occasional Paper 5 of 1988.

Government of India (1997) *District Level Estimates of Fertility and Child Mortality for 1991 and their Inter Relations with Other Variables.* New Delhi, Office of the Registrar General. Occasional Paper 1 of 1997.

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

Government of India (2013) *The National Policy for Children, 2013*. New Delhi, Ministry of Women and Child Development.

Guilmoto CZ, Saikia N, Tamrakar V, Bora JK (2018) Excess under-5 female mortality across India: a spatial analysis using 2011 census data. *Lancet Global Health*. E650-658.

Houwelling TAJ, Kunst AE, Huisman M, Mackenbach JP (2007) Using relative and absolute measures for monitoring health inequalities: experiences from cross-national analyses on maternal and child health. *International Journal for Equity in Health* 6(15).

Mackenbach JP (2015) Should we aim to reduce relative or absolute inequalities in mortality? *European Journal of Public Health* 25(2): 185.

Moultrie T, Dorrington R, Hill A, Hill K, Timæus, Zaba B ((2013) *Tools for Demographic Estimation*. Paris, International Union for the Scientific Study of Population.

Mishra V, Palmore JA, Sinha SK (1994) *Indirect Estimates of Fertility and Mortality at the District Level, 1981*. New Delhi, Office of the Registrar General. Occasional Paper 4 of 1994.

Naeye RL, Burt LS, Wright DS, Blanc WA, Tatter D (1971) Neonatal mortality, the male disadvantage. *Pediatrics* 48(6): 902-906.

Preston SH, Weed JA (1976) Causes of death responsible of international and intertemporal variation in sex mortality differentials. *World Health Statistics Quarterly*

Rajan SY, Nair PM, Sheela KL, Jagatdeb L, Mishra NR (2008) *Infant and Child Mortality in India: District Level Estimates*. New Delhi, Population Foundation of India.

Scanlan JP (2000) Race and mortality. *Society* 37: 29-35.

Selvin S (1996) *Statistical Analysis of Epidemiological Data*. New York, Oxford University Press.

Tukey JW (1977) *Exploratory Data Analysis*. Reading, Massachusetts, Addison-Wesley Publishing Company.

United Nations (2011) *Sex Differentials in Childhood Mortality*. New York, Department of Economic and Social Affairs. Population Division.

Wisser O, Vaupel JW (2014) The sex differential in mortality: A historical comparison of the adult-age pattern of the ratio and the difference. Max Plank Institute of Demographic Research. MPIDR Working Paper WP 2014-05.