

Tamil Nadu and the Diagonal Divide in Sex Ratios

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Between 1961 and 2001, India's 0-6 sex ratio has steadily declined. Despite evidence to the contrary, this ratio is often characterised in terms of a diagonal divide with low 0-6 sex ratios in northern and western India and normal 0-6 sex ratios in eastern and southern India. While unexpectedly high rates of female infant mortality have been reported in Tamil Nadu, it is still regarded as lying outside the ambit of states with unusually low 0-6 sex ratios. Based on an analysis of patterns in sex ratio at birth, infant mortality rates and under-5 mortality rates for Tamil Nadu, this paper traces the development of daughter deficit in the state and examines the validity of the diagonal divide in sex ratios across India. We find evidence of daughter deficit in more than half the state's districts with a majority of the shortfall arising before birth. The evidence presented here, combined with earlier work on declining 0-6 sex ratios outside north-western India, suggests that the diagonal divide is no longer an appropriate distinction.

1 Introduction

The phenomenon of missing women is well-established in India. Based on Census 2001, Klasen and Wink (2003) estimate that about 39 million women are missing. Underlying this estimate, the population sex ratio in India has declined from 972 in 1901 to 933 in 2001 and the 0-6 sex ratio, that is, the proportion of girls to boys has declined from 976 in 1961 to 927 in 2001 (Table 1, p 57).

Various factors such as nutrition (Goodkind 1996), incidence of hepatitis-B virus (Oster 2005), and parental hormonal levels (James 1996), among others, may influence sex ratios at birth (SRB) and therefore the 0-6 sex ratio. In the Indian context, Oster (2005) argues that, in part, the level of the unexpectedly masculine SRB may be driven by the incidence of hepatitis-B virus while Jayaraj and Subramanian (2004) argue that, in part, the declining trend in the female-male SRB may be attributed to improvement in women's health status. While these explanations may account for some of the inequality in sex ratios, the differential survival of girls and boys due to practices like infanticide, neglect, and sex selective abortion cannot be denied. For instance, based on an analysis of SRB, Jha et al (2006) find that about 10 million female fetuses may have been aborted during 1985-2001.

Conventionally, much of the daughter shortfall has been accounted for by states such as Punjab, Haryana and Delhi in the north and Gujarat and Maharashtra in the west. An early essay on India's demography (Visaria 1967) demonstrated that sex ratios were persistently lower (i.e., more masculine) in the northern states, and higher in the south. More than a decade later, Sopher (1980: 296) commented that the "completeness of the regional dichotomy is impressive". Dyson and Moore (1983) confirmed this pattern and grouped the major Indian states into two broad demographic regimes divided by a diagonal line that approximated the contours of the Satpura hill range, extending eastward to join the Chhotanagpur hills of southern Bihar. Miller's (1989: 1232) analysis of changes in juvenile sex ratios between 1961 and 1971 confirmed the diagonal divide.

More recently, analysis of changes in the 0-6 ratio between 1991 and 2001 shows that, except for Lakshadweep, Sikkim, Mizoram, Tripura and Kerala, all states have registered a decline in the ratio, prompting the conclusion that "the traditional north-south divide stands significantly modified" (Agnihotri 2003: 4351). For example, Agnihotri (2003) shows that the 0-6 sex ratio for Orissa has declined from 971 in 1991 to 953 in 2001 and that in 2001, 12 districts had a 0-6 sex ratio lower than 952 as against two in 1991.¹ A similar pattern is observed in other eastern states.

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Nine out of 18 districts in West Bengal have an urban 0-6 sex ratio below 952 while it is 927 in Kolkata. Fourteen of 23 districts in Assam display an urban 0-6 sex ratio less than 952.

Despite evidence that the diagonal divide may no longer be valid, there is a tendency to persist with this distinction. For instance, based on Census 2001 data on SRB, Bhat and Zavier conclude that the SRB in the southern and eastern states of India “is well

Table 1: Population Sex Ratio, 0-6 Sex Ratio in India and Tamil Nadu

Year	1901	1911	1921	1931	1941	1951	1961	1971	1981	1991	2001
1: Population Sex Ratio-India	972	964	955	950	945	946	941	930	934	927	933
2: Population Sex Ratio-Tamil Nadu	1,044	1,042	1,029	1,027	1,012	1,007	992	978	977	974	986
3: 0-6 Sex Ratio-India	.	.	.	.	.	.	976	964	962	945	927
4: 0-6 Sex Ratio-Urban India	.	.	.	.	.	.	.	.	.	935	903
5: 0-6 Sex Ratio-Rural India	.	.	.	.	.	.	.	.	.	948	934
6: 0-6 Sex Ratio-Tamil Nadu	.	.	.	.	1,010 ^a	999 ^a	985	974	967	948	942
7: 0-6 Sex Ratio-Urban Tamil Nadu	.	.	.	.	.	.	.	.	.	955	951
8: 0-6 Sex Ratio-Rural Tamil Nadu	.	.	.	.	.	.	.	.	.	945	931

Ratios are defined as number of females per 1,000 males. ^a0-4 sex ratio, from Chunkath and Athreya (1997).

Sources: Figures are based on census data (a) Rows 1 and 2, from 1901 to 1961, Visaria (1969), (b) Rows 1 and 2, from 1981 to 2001, Planning Commission (2002), (c) Rows 3 and 6, Premi (2001), (d) Rows 4, 5, 7 and 8, and (e) *Census India*, Issue 15 (2003), Office of the Registrar General, India.

within the range observed in normal circumstances”. They also note that, “a line drawn diagonally separating south and eastern India from north and western India would neatly demark the two regions of low and high SRB. Except for some *isolated* pockets (such as around Salem district in Tamil Nadu)... (ibid: 2296, emphasis added)”. However, even based on their definition of a normal range, between 943 and 971, the prevailing SRB of 935 in Tamil Nadu (919 in rural Tamil Nadu) and of 926 in Orissa, clearly falls outside the normal range.² Similarly, Bhaskar and Gupta (2007) note that south and east India exhibit international patterns in child sex ratio as against the unbalanced sex ratios in the northern and western states. While noting that “*pockets* of south India are infamous for infanticide” (Patel 2007: 41, emphasis added), a recent book on sex selective abortion does not contain any essay on the prevalence of the practice in southern and eastern states.

Set against this background, this paper has three aims. First, to use data from Tamil Nadu to examine the validity of the diagonal divide, second, to use information on SRB, infant mortality rates (IMR) and under-5 mortality rates (U5MR) to analyse state-level temporal patterns in daughter deficit and third, to provide a district-level analysis of daughter deficit. A district-level assessment highlights intra-state variations while analysis of the SRB, IMR and U5MR provides an estimate of the extent of pre-birth, early (within a year after birth) and late (between age 1 and 5) post-birth daughter deficit in Tamil Nadu.³

The following section of the paper describes the data, Section 3 discusses benchmarks established for assessing the deficit, Section 4 presents the extent of daughter deficit while the final section concludes.

2 Data

An intra-state assessment of daughter deficits requires district-level data on SRB, IMR, and U5MR. Indian data on vital events comes from the Sample Registration System (SRS), a countrywide annual survey of vital events covering 1.1 million households in each round. The SRS supports state-level but not district-level analyses. Fortunately, the 2001 Census provides, for the first time, district-specific data on live births. Accordingly, the district-specific SRB

presented in this paper are based on 8,95,765 births recorded in Tamil Nadu in Census 2001.

In addition, we use various rounds of Vital Events Surveys (VES) conducted by the Directorate of Public Health (DPH) of Tamil Nadu for the birth years 1996 to 1999 and for the birth year 2003. These surveys track vital events at the district level. The data available in each VES, nine million individuals and about 1,74,000 births, may be contrasted with the SRS surveys which cover 3,55,000 individuals and 6,000-7,000 births in the state in each round. Each VES covers 3,00,000 individuals per district and provides data on SRB and infant deaths disaggregated by district and gender (for details see Athreya 1999). Information from VES 1996 to 1999 is pooled to provide SRB and IMR estimates for the late 1990s

while information from VES 2003 is used to compute district-specific IMR estimates for the early 2000s. Information on gender-specific U5MR is available only at the state-level and as discussed below, this information is combined with infant mortality data to compute estimates of mortality in the age group 1-5.

3 Benchmarking and Measuring Daughter Deficits

Daughter deficit, defined as the gap between the number of expected daughters and the number of daughters born or alive in a certain age group, may occur before birth, within a year after birth (early post-birth deficit) or in the age group 1-5 (late post-birth deficit).⁴ This section considers how these deficits may be identified and establishes an “expected” ratio against which prevailing ratios may be compared.

Pre-Birth Daughter Deficit

International evidence on expected SRB in countries without pre-birth interference is available from several sources. Based on 240 years of Swedish data, Johansson and Nygren (1991), henceforth JN, conclude that the SRB is “biologically very stable” and close to 952 females per 1,000 males. JN also analyse data from 12 other western industrialised countries for the period 1970-84 and conclude that the SRB in these countries conforms to patterns found in Swedish data. We updated these numbers using data from United Nations (2004) and computed SRB for all countries with a relatively complete civil registration system (at least 90%) with 1,70,000 or more live births per year (about the number recorded in Tamil Nadu’s VES) and with no record of pre-birth interference. The SRB for the set of 16 countries which satisfied these criteria lies between 932 and 965 with a weighted mean of 948.⁵ Clearly, there is variation in the SRB across countries but given the number of factors that may have a bearing on SRB, it lies in a narrow range.

In the Indian context, the expected SRB may be obtained by examining SRB at a time when accurate pre-birth sex selection must have been difficult. The earliest source that we have located is Ramachandran and Deshpande (1964), henceforth RD. Based on 1.93 million births in hospitals and health centres between 1949 and 1958, RD report an all-India SRB of 943 and based on

7,36,216 births a SRB of 943 for south India. While hospital data reflect a small proportion of births, RD conclude that given their large sample size it is likely that the hospital sex ratio is a “valid indicator of the order of magnitude of the SRB for the population”. While RD’s figures are based on actual birth data, estimates of the Indian SRB based on the link between SRB and life expectancy at birth have been computed by Klasen and Wink (2003) and Sudha and Rajan (2003). Both report an expected SRB of 961-962.

To benchmark pre-birth daughter deficit, we work with the average of the (south) India-specific estimates of 943 and 962. That is, we use 952 female live births per 1,000 male live births as the sex ratio which may be expected in India and Tamil Nadu in the absence of interference. Thus, pre-birth daughter deficit (DD_{pre}), defined as the gap between the number of expected girls and the number of girls born is calculated as,

$$DD_{pre} = N_m SRB_e - N_f \quad \dots(1)$$

N_m and N_f denote the number of live male and female births and SRB_e denotes expected SRB.

3.1 Early Post-Birth Daughter Deficit

IMR, defined as mortality in the age group 0-365 days and expressed as infant deaths per 1,000 live births is usually higher for males. Based on a review, Waldron (1983) concludes that, “in most available data males have had higher mortality than females during the first year of birth”. JN (1991) analyse male and female infant deaths in several countries for the period 1976-84, and conclude that there is a “natural” ratio of 77 female deaths for every 100 male infant deaths. Based on data from United Nations (2004), and for the same set of countries that satisfy the criteria used to establish the SRB benchmark, we find that the ratio of female to male infant deaths ranges from 71 to 83 with a weighted mean of 76.5.⁶

Working with a naturally occurring SRB of 952 females per 1,000 males and a potential range of 71 to 83 female infant deaths for every 100 male infant deaths, yields an expected female IMR of between 75 (71/0.952) and 87 (83/0.952)% of the male IMR. Based on the weighted mean of the ratio of female to male infant deaths we define the expected female IMR as 80% of the male IMR (76.5/.952). Thus, early post-birth daughter deficit (DD_{epost}) is written as,

$$DD_{epost} = \{FIMR_s - (0.8 * MIMR_s)\}N_f \quad \dots(2)$$

$FIMR_s$ and $MIMR_s$ are estimated female and male infant mortality rates, respectively. Alternatively, (2) may be written as,

$$DD_{epost} = \{FIMR_s - FIMR_e\}N_f \quad \dots(3)$$

where $FIMR_e$ denotes the expected female IMR.

Post-birth deficit for Tamil Nadu is computed from ves based estimates (whereas pre-birth daughter deficit is based on census data). The ves data yield estimates of male and female IMR which help identify districts with evidence of early post-birth daughter deficit. However, an assessment of the absolute post-birth deficit, as in (3), requires information on the total number of female live births (N_f). This information is only available from Census 2001, while the IMR data are from ves 2003. As long as there has been no major change in birth rates between this period, census

information on the total number of female live births may be used to compute (3). According to *SRS Bulletin* (Vol 36, No 2), in 2001, the birth rate in Tamil Nadu was 19 per 1,000 while it was 18.3 in 2003 (*SRS Bulletin*, Vol 39, No 1). Both of these are survey-based estimates and it is unlikely that they are statistically different from each other, which suggests that information on female live births from Census 2001 may be used.

3.2 Late Post-Birth Daughter Deficit

To compute post-birth deficit in the age group 1-5 we need gender-specific mortality rates for this age group. While district level mortality rates for this age group are unavailable, state-level information on $U5MR$, at least for some years, is available and mortality rates for the age group 1-5 may be obtained by subtracting the IMR from the $U5MR$.⁷ However, before computing this rate we need to establish a benchmark for $U5MR$.

To establish this, we examined mortality patterns in the same set of countries used to establish benchmarks for SRB and IMR. Unfortunately, the various editions of the *UN Demographic Yearbook* contain information on age-specific mortality rates for the age group 0-4 and not for 0-5. While we are forced to use this information, it is unlikely that the male-female mortality gap in the two age groups differs substantially. Data on mortality patterns for these countries shows that the ratio of female to male deaths in the age group 0-4 ranges from 72 to 83 female deaths for every 100 male deaths with a median of 78 and a weighted mean of 77. These figures are similar to those obtained for defining the IMR benchmark and suggest that expected female mortality rate in the age group 0-5 may also be pegged at about 80% of the male mortality rate. Thus, post-daughter deficit (DD_{lpost}) in the age group 1-5 is defined as the gap between the estimated and expected female mortality rate, times the number of female births, and is written as,

$$DD_{lpost} = \{(FU5MR_s - FIMR_s) - (0.8 * (MU5MR_s - MIMR_s))\}N_f \quad \dots(4)$$

$FU5MR_s$ and $MU5MR_s$ are estimated female and male under-5 mortality rates. Alternatively, (4) may be written as,

$$DD_{lpost} = \{FCMR_s - FCMR_e\}N_f \quad \dots(5)$$

where $FCMR_s$ and $FCMR_e$ are estimated and expected female child mortality rates in the age group 1-5.

Combining (1), (3) and (5), we obtain total daughter deficit (TD) as,

$$TD = (N_m SRB_e - N_f) + \{FIMR_s - FIMR_e\}N_f + \{FCMR_s - FCMR_e\}N_f \quad \dots(6)$$

4 Estimates

This section presents estimates of 0-6 and birth sex ratios as also the temporal and spatial patterns of infant mortality.

4.1 Temporal and Spatial Patterns in 0-6 and Birth Sex Ratios

We begin by discussing the figures in Table 1. As shown there, between 1961 and 2001, the all India 0-6 sex ratio fell from 976 to 927, a decline of 49 points. Over the same period the 0-6 sex ratio

in Tamil Nadu fell by 43 points from 985 to 942. While the absolute level of the 0-6 sex ratio in Tamil Nadu in 2001 is 15 points higher than the Indian 0-6 sex ratio and 144 points higher than Punjab (798) and 59 points higher than Gujarat (883), the decline in Tamil Nadu's 0-6 sex ratio between 1961 and 2001 is clearly not very different from the all-India pattern.

While the overall trend in the 0-6 sex ratio in Tamil Nadu and India are similar, there are intriguing differences between urban Tamil Nadu and urban India. As Table 1 shows, in 1991, the 0-6 sex ratio in urban Tamil Nadu was 955, 20 points higher than the corresponding number for urban India. While, in 1991, the 0-6 sex ratio of 945 in rural Tamil Nadu was three points lower than the corresponding ratio in rural India. These differences persist in 2001. Between 1991 and 2001, Tamil Nadu's urban 0-6 sex ratio declined by four points compared to a decline of 32 points for urban India, exacerbating the sex ratio gap between urban India and urban Tamil Nadu from 20 points in 1991 to 48 in 2001. In marked contrast, the 14-point decline in the 0-6 ratio in rural Tamil Nadu from 945 to 931 is the same as the decline in rural India and Tamil Nadu's rural 0-6 sex ratio remains lower than the 0-6 sex ratio for rural India. In fact, in 2001, Tamil Nadu is one of the few states in India where the rural 0-6 ratio is lower than the urban 0-6 ratio.⁸

Table 2 provides information on SRB for India and Tamil Nadu. Between 1978-92 and 2001 the Indian SRB fell from 943 to 909, a drop of 34 points. Over the same period, the Tamil Nadu SRB declined from 980 to 935, a decline of 45 points. While the Tamil Nadu SRB is 26 points higher than the Indian SRB in 2001, it is lower than the expected sex ratio of 952 and the state's decline outpaces the country-wide decline in SRB. Similar to the patterns for the 0-6 sex ratio, there are differences between urban and rural Tamil Nadu. In 2001, the SRB was 960 in urban Tamil Nadu and 919 in rural Tamil Nadu.

Table 2: SRB in India and Tamil Nadu

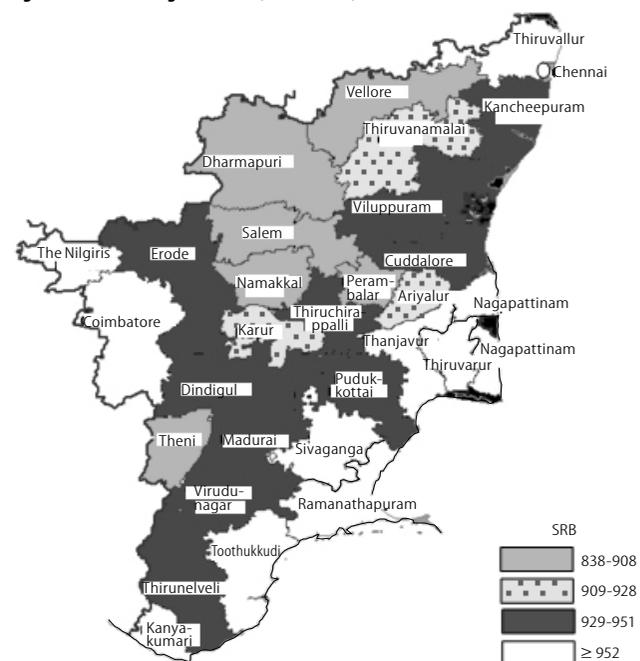
Period/Statistic	Source	India	India Urban	India Rural	Tamil Nadu	Urban Tamil Nadu	Rural Tamil Nadu
1: 1978-92	NFHS-1	943	.	.	980	.	.
2: 1984-98	NFHS-2	926	.	.	952	.	.
3: 1981-90	SRS	909	.	.	952	.	.
4: 1996-98	SRS	901	.	.	952	.	.
5: 1998	SFMS	899	878	903	.	.	.
6: 1996-99	VES	.	.	.	935	943	932
(95% confidence interval)					(931-940)	(935-952)	(927-937)
Number of births – female/male					3,35,712/3,58,893	1,00,380/1,06,406	2,35,332/2,52,487
7: 2001	Census	909	901	909	935	960	919
Number of births – female/male					4,32,923/4,62,842	1,77,230/1,84,609	2,55,693/2,78,233

Sources: (a) Row 1 to row 4, Retherford and Roy (2003), (b) Row 5, Jha et al (2006), (c) Row 6, based on VES, and (d) Row 7, Census 2001, Table F-9.

Notwithstanding the differences between urban Tamil Nadu and urban India, the temporal analysis of the 0-6 sex ratio and the SRB clearly displays that the state is *not* an exception to the countrywide decline in these ratios.

Beyond statewide trends, Table 3 (p 60) presents district-specific information on SRB. These estimates show that the SRB is lower than 952 in 19 of the state's 30 districts (see the figure). There are differences between urban and rural areas with evidence of pre-birth deficit in the urban areas of "only" 10 districts as opposed to

Figure: Pre-Birth Daughter Deficit, Tamil Nadu, Census 2001



rural areas of 22 districts. While Salem has the lowest SRB of 838, the idea that low SRB is restricted to certain pockets of the state around Salem district is incorrect. More than two-thirds of the rural parts of the various districts have SRB which are 4 to 146 points lower than the expected SRB and about a third of the urban parts of the various districts display SRB that are 1 to 72 points lower than the expected SRB.

4.2 Temporal and Spatial Patterns in Infant Mortality

Between 1981 and 2003 there is a sharp decline in overall IMR for Tamil Nadu (Table 4, p 60). In 1981 (Table 4, row 1), based on census estimates, Tamil Nadu's female IMR was 93 while male IMR was 114. At 93, actual female IMR is slightly higher than the expected female IMR of 91.2 (0.8 times 114), suggesting limited incidence of early post-birth daughter deficit. IMR data from NFHS-1 for the period 1982-91 (Table 4, row 3) also reveals a similar pattern of higher male than female IMR (79 versus 63) and the estimated female IMR is lower than the expected female IMR of 63.2 (0.8 times 79), suggesting limited (no) incidence of early post-birth deficit. In contrast, while srs 1981 also displays (Table 4, row 2) higher male IMR (93 versus 89), the gap between male and female IMR is not large and translates into an expected female IMR of 74.4 versus an estimated female IMR of 89, suggesting a fairly high incidence (14.6 point gap) of early post-birth deficit.

While the sensitivity (to data source) of the extent of early post-birth deficit in the 1980s is a concern, for the 1990s and the 2000s, regardless of data source the gap between estimated and

Table 3: SRB and Pre-Birth Deficit, Tamil Nadu, Census 2001

	Overall		Urban		Rural	
	SRB (1)	Deficit (2)	SRB (3)	Deficit (4)	SRB (5)	Deficit (6)
Tamil Nadu	935	11,471	960	1,637	919	9,834
Ariyalur	923	181	955	0	920	181
Chennai	979	0	979	0	.	.
Coimbatore	963	0	964	0	961	0
Cuddalore	930	409	932	114	929	295
Dharmapuri	869	2,212	936	58	859	2,154
Dindigul	934	256	955	0	923	256
Erode	934	362	962	0	910	362
Kancheepuram	949	191	964	0	934	191
Kanyakumari	988	0	1000	0	968	0
Karur	910	296	941	272	895	24
Madurai	951	228	973	0	925	228
Nagapattinam	982	0	975	0	984	0
Namakkal	859	885	916	119	829	766
Nilgiris	988	0	963	0	1,023	0
Permabalur	896	237	903	29	894	208
Pudukottai	935	219	879	145	945	74
Ramanathapuram	990	0	1019	0	981	0
Salem	838	2,567	880	694	806	1,873
Sivaganga	955	0	952	0	956	0
Thanjavur	962	45	994	0	948	45
Theni	895	444	924	114	862	330
Thirunelveli	946	137	944	83	948	54
Thiruvallur	953	170	971	0	936	170
Thiruvannamalai	922	680	1,016	0	905	680
Thiruvarur	967	0	999	0	960	0
Thuthukudi	956	83	977	0	941	83
Tiruchirappalli	951	111	964	0	941	111
Vellore	907	1250	951	9	885	1,241
Villupuram	938	328	955	0	936	328
Virudhunagar	945	180	966	0	930	180

Total state deficit is the sum of the deficit in each district. Total deficit for each district is the sum of deficits in the urban and rural parts of the district.
Source: Based on Census 2001, Table F-9.

expected female IMR lies in a narrow range. For instance, in 1991 (Table 4, rows 4 and 5), according to census-based estimates the gap between estimated and expected female IMR is seven points while it is six points on the basis of SRS 1991. During the rest of the 1990s, the three available data sources for the period reveal the presence of early post-birth daughter deficit with the gap between estimated and expected female IMR lying in a narrow range of 9.8 to 11.6 points (Table 4, rows 6-8).

For the early 2000s, female IMR dropped from 39 in the period 1996-99 to 29.7 by 2003 (Table 4, row 9), but it was still higher than the expected female IMR of 24. The difference of 5.7 points between the estimated and expected female IMR is statistically significant suggesting the continued presence of early post-birth daughter deficit in the 2000s. While statistically

significant in both urban and rural areas, the gap is seven points in rural areas and relatively muted for urban areas where the gap is 1.8 points. While IMR figures based on SRS 2003 are higher than those based on VES 2003, a similar pattern of decline in female IMR from 53 in 1996 to 41 in 2003 (Table 4, rows 7 and 10) can be observed. The gap between estimated and expected female IMR in 2003 is about 5.8 points. Thus, regardless of data source the gap between estimated and expected female IMR are similar.

Beyond state-level patterns, district-specific numbers presented in Table 6 (p 61) show that the estimated female IMR is higher than the expected female IMR in nine districts. There is a large gap between urban and rural areas with evidence of early post-birth daughter deficit in the urban areas of one district as opposed to the rural areas of 10 districts.

4.3 Sex Ratios and Sources of Daughter Deficit

To examine the development of sex ratios up to age 6 and to identify the extent of daughter deficit occurring in each age group, consider the information on SRB, IMR, U5MR and the 0-6 sex ratio presented in Table 5 (p 61). Where possible we try to use data from a single source for each year. While the analysis is limited by data availability and is based on cross-section patterns (ideally one should follow a birth cohort over time) the figures are, nevertheless, revealing.

Consider Table 5, row 1, according to these figures, in 1981, the SRB in Tamil Nadu was 969 suggesting that there was no pre-birth deficit at this time. Male IMR is pegged at 114 and female IMR at 93; given the higher male IMR this translates into a 0-1 sex ratio of 989. The male U5MR is 134 while it is 131 for girls, implying that in the age group 1-5, the male mortality rate (U5MR-IMR) was far less than that for girls (20 per 1,000 male live births versus 38 per 1,000 female live births). This 18 point gap translates into a decline in the 0-1 sex ratio from 989 to the 0-5 sex ratio of 968. While, the decline from a SRB of 969 to a 0-6 sex ratio of 967 suggests post-birth daughter deficit, the main insight is that, higher 1-5 female mortality (1.9 times the male mortality) is the main source of daughter deficit. The gap between actual

Table 4: IMR in Tamil Nadu

Year/Statistic	Source	Overall			Urban			Rural		
		Male	Female	Expected Female	Male	Female	Expected Female	Male	Female	Expected Female
1: 1981	NHDR	114	93	91.2	.	.	.	.	.	.
2: 1981	SRS	93	89	74.4	.	.	.	.	.	.
3: 1982-91 (mid-point 1986)	NFHS-1	79	63	63.2	.	.	.	.	.	.
4: 1991	NHDR	55	51	44	.	.	.	.	.	.
5: 1991	SRS	60	54	48	43	40	34.4	69	61	55.2
6: 1989-98 (mid-point 1993)	NFHS-2	50.2	51.8	40.2	.	.	.	.	.	.
7: 1996	SRS	54	53	43.2	42	34	33.6	59	61	47.2
8: 1996-99	VES	36	39	28.8	23	19	18.4	41	48	32.8
Absolute value of test statistic			23.5			1.01				26.8
p-value ^a			(0.000)			(0.313)				(0.000)
9: 2003	VES	30	29.7	24	24	21	19.2	32.6	33.1	26.1
Absolute value of test statistic			7.20			1.43			7.11	
p-value ^a			(0.000)			(0.152)			(0.000)	
10: 2003	SRS	44	41	35.2	32	31	25.6	44	41	35.2

IMR-number of infant deaths (age 0-365 days) per 1,000 live births. ^aH0: Estimated FIMR is equal to expected FIMR. Sources: (a) Row 1 and row 4, Planning Commission (2002), (b) Rows 2, 5, 7 and 10, *SRS Bulletins*; Row 2 (Vol 19, No 1), rows 5 and 7 (Vol 31, No 1), row 10 (Vol 39, No 1), (c) Row 3, Pandey et al (1998), row 6, www.nfhsindia.org/data/tn/tncchap6.pdf, and (d) Row 8 and 9 are based on VES.

and expected female U5MR is 23.8 ($131 - 0.8 \times 134$), most of which is accounted for by deficit in the age group 1-5 ($38 - 0.8 \times 20 = 22$), while early post-birth deficit accounts for the remaining gap ($93 - 0.8 \times 114 = 1.8$). Thus, in 1981 these numbers suggest no pre-birth daughter deficit; about 7% early post-birth daughter deficit and 93% late-post birth daughter deficit.⁹

In 1991 (Table 5, row 3) as in 1981, the SRB in Tamil Nadu was 952, suggesting no pre-birth daughter deficit. A male IMR of 55 and a female IMR of 51 translates into a 0-1 sex ratio of 955. The male U5MR is 64 while it is 70 for girls, implying that in the age group 1-5 the male mortality rate was less than that for girls (9 per 1,000 male live births versus 19 per 1,000 female live births). This 10 point gap translates into a decline in the 0-1 sex ratio from 955 to 942 for the 0-5 group, which becomes favourable to girls in the age group 5-6 to reach 948 for the age group 0-6. The decline from a SRB of 952 to a 0-6 sex ratio of 948 suggests post-birth daughter deficit. The main point is that while the higher female 1-5 mortality (2.1 times the male mortality) is still the main source of daughter deficit, its share has declined as compared to 1981 and early post-birth deficit has become higher than in 1981. The gap between actual and expected female U5MR is 18.8 ($70 - 0.8 \times 64$), most of which is accounted for by deficit in the age group 1-5 ($19 - 0.8 \times 9 = 11.8$), while early post-birth deficit accounts for the remaining gap ($51 - 0.8 \times 55 = 7$). Thus, in 1991 these numbers suggest no pre-birth deficit, about 37% early post-birth deficit and 63% late-post birth deficit.

During 1996-99 (Table 5, row 5), unlike the previous years, the VES-based SRB of 935 is well below the benchmark of 952 suggesting the presence of pre-birth daughter deficit. In contrast to 1981 and 1991, female IMR is higher than male IMR which translates into a less favourable 0-1 sex ratio of 929. Since we do not have information on U5MR or the 0-6 sex ratio for this period we cannot say more. Combining information from Census 2001 and SRS 2001 (Table 5, row 6) allows us to construct the situation in 2001. The SRB remains at 935, implying pre-birth daughter deficit; female IMR continues to be higher than male IMR translating into a 0-1 sex ratio of 923. In sharp contrast to 1981 and 1991, by age 6 the sex ratio rises to 942. Thus, starting with a SRB of 935 and falling to a 0-1 sex ratio of 923, the 0-6 sex ratio has become favourable to girls, which in turn suggests that in 2001, unlike 1981 and 1991, male mortality between 1 and 6 is *much higher* than female mortality and that daughter deficit is unlikely to emanate from the age group 1-6. While we do not have figures for under-5 mortality, the increase in the sex ratio

from (0-1) 923 to (0-6) 942 suggests that in 2001, male and female U5MR matches the internationally expected pattern of higher male mortality. Overall, these numbers show clear evidence of pre-birth and early post-birth daughter deficit and do not support a substantial role for late post-birth daughter deficit.

Beyond 2001, IMR data from SRS 2003 and VES 2003 (Table 5, rows 7 and 8) is used to compute early post-birth deficit. Based on SRS 2003, early post-birth daughter deficit is 5.8 ($41 - 0.8 \times 44$) and based on VES 2003 early post-birth daughter deficit is 5.7

Table 5: Development of Sex Ratios and Sources of Female Deficit in Tamil Nadu

Year	SRB	MIMR	FIMR	0-1 Sex Ratio	Under 5 MMR	Under 5 FMR	0-5 Sex Ratio	0-6 Sex Ratio
1: 1981	969	114	93	989	134	131	968	967
1: 1981	952	93	89	951	.	.	.	.
1: 1991	952	55	51	955	64	70	942	948
1: 1991	952	60	54	955	.	.	.	.
5: 1996-99	935	36	39	929	.	.	.	.
1: 2001	935	45	54	923	.	.	.	942
7: 2001(SRB) and 2003 (IMR)	935	44	41	935	.	.	.	.
8: 2001(SRB) and 2003 (IMR)	935	30	29.7	934	34	.	.	.

Sources: (a) Rows 1 and 3, Planning Commission (2002)-SRB figures are weighted averages of the rural and urban SRB, (b) SRB figures-row 2 and row 4, are SRS-based estimates for the period 1981-90 to 1996-98, Retherford and Roy (2003). IMR figures for 1981 and 1991 are from SRS *Bulletin*, Vol 19, No 1 and Vol 31, No 1, respectively, (c) Row 5, based on VES, (d) SRB figures, rows 6, 7 and 8, Census 2001, Table F-9; IMR figures, rows 6 and 7, SRS *Bulletin*, Vol 37, No 1 and Vol 39, No 1, respectively, and (e) IMR figures, row 8 are based on VES; U5MR, *Health Indicators 2003*, Government of Tamil Nadu.

Table 6: Male and Female IMR and Post-Birth Daughter Deficit, Tamil Nadu (2003)

	MIMR Overall	FIMR Overall	Deficit Overall	MIMR Urban	FIMR Urban	Deficit Urban	MIMR Rural	FIMR Rural	Deficit Rural
Tamil Nadu	30	29.7	1,829	24	21	26	32.6	33.1	1,799
Chennai	17	14	2	17	14	2	.	.	.
Coimbatore	23	19	11	15	13	14	25	21	2
Cuddalore	32	31	98	32	22	0	32	35	110
Dharmapuri	39	40*	219*	21	16	0	45	49*	258*
Dindigul	31	48*	289*	33	35	37	30	54*	241*
Erode	32	25	0	26	18	0	34	28	3
Kancheepuram	23	21	58	23	21	21	23	22	31
Kanyakumari	.	.	.	26	11	0	.	.	.
Karur	34	34	41	26	31	21	37	35	22
Madurai	28	35*	230*	22	20	19	30	42*	138*
Nagapattinam	32	29	40	25	26	14	34	30	24
Namakkal	26	21	4	13	9	0	31	26	7
Nilgiris	28	24	12	20	26	33	32	24	0
Perambalur	31	38*	49*	.	.	.	31	38*	42*
Pudukottai	28	30*	92*	20	19	6	31	35*	97*
Ramanathapuram	34	31	36	27	31	22	37	31	11
Salem	33	41*	283*	29	33	83	35	45*	178*
Sivaganga	28	20	0	27	10	0	28	24	8
Thanjavur	33	23	0	18	13	0	38	26	0
Theni	33	39*	88*	28	31	31	35	42*	46*
Thirunelveli	37	32	59	38	31	11	36	32	42
Thiruvallur	25	22	35	16	15	25	28	24	13
Thiruvannamalai	30	29	82	25	18	0	32	34	107
Thiruvarur	28	21	0	13	26*	26*	34	19	0
Thuthukudi	30	27	37	24	20	7	33	30	27
Tiruchirappalli	29	37*	230*	30	24	6	29	42*	182*
Vellore	33	40*	349*	24	20	1	36	48*	312*
Villupuram	32	32	143	33	22	0	32	36*	195*
Virudhunagar	34	30	37	24	28	52	38	31	3

IMR- number of infant deaths (age 0-365 days) per 1,000 live births. The state total is based on districts where the difference between estimated and expected SRB is statistically different.* Indicates estimated FIMR is statistically greater than expected FIMR at at least 5% significance level.

Source: Based on VES 2003.

($29.7 - 0.8 \times 30$) as compared to a pre-birth daughter deficit of 17 in 2001 (based on SRB from Census 2001). While we do not have gender-specific U5MR for 2003, we do have information on overall U5MR. According to VES 2003, overall U5MR is 34.¹⁰ Using weights based on the number of boys and girls at birth (0.52 and 0.48, respectively) and based on the extreme assumption that as in 1981 and 1991 female mortality in the age group 1-5 is twice that of male mortality leads to a male U5MR of 32.7 (that is, an IMR of 30 and an U5MR of 32.7) and a female mortality rate of 35.4 (an IMR of 29.7 and an U5MR of 35.4).¹¹ The gap between estimated and expected female U5MR is 9.24 ($35.4 - 0.8 \times 32.7$). Most of this gap is accounted for by daughter deficit in the age group 0-1, ($29.7 - 0.8 \times 30 = 5.7$) while late post-birth daughter deficit accounts for the remaining gap ($5.7 - 0.8 \times 2.7 = 3.54$). Thus, based on this extreme assumption we get a late post-birth daughter deficit of 3.54, early post-birth daughter deficit of 5.7 and a pre-birth daughter deficit of 17. These figures translate into a 65% share for pre-birth daughter deficit, 22% due to early post-birth daughter deficit and at most 13% to late post-birth daughter deficit. Even if we work with higher IMR figures from SRS 2003 (about 1.36-1.41 times VES 2003) and correspondingly assume a higher U5MR of 48 (about 1.4 times VES 2003) and continue with the assumption that, as in 1981 and 1991 female 1-5 mortality is twice that of male mortality, in terms of their relative shares, at most 15% of total daughter deficit may be attributed to late post-birth daughter deficit.

Overall, the state-level analysis reveals sharp temporal changes in the relative contributions to daughter deficit. Between 1981 and 2001 the contribution of late post-birth daughter deficit declines sharply, the share of pre-birth daughter deficit rises sharply while the share of early post-birth daughter deficit remains relatively stable. For the 1980s and 1990s, the data support a division of total daughter deficit into early and late post-birth deficit while for the latter half of the 1990s and early 2000s the data support a division of total daughter deficit into pre-birth and early post-birth daughter deficit.

4.4 Spatial Patterns in Daughter Deficit

Given the foregoing discussion, since the district-specific data are from the early 2000s, we use a two part division of total daughter deficit into pre-birth and early post-birth deficit to compute district-level patterns. The total pre-birth daughter deficit in 2000 was 11,471 (Table 3), the bulk of which emanates from rural areas (about 86% of the shortfall). While there is evidence of deficit in rural areas of 22 districts, much of the deficit is concentrated in Salem (23%), Dharmapuri (19.6%), Vellore (11%) and Namakkal (7.8%). Estimates of early post-birth daughter deficit based on Census 2001 and VES 2003 data are provided in Table 6. The total estimated early post-birth deficit is 1,829 daughters, almost all of which may be attributed to the rural areas of the state. In terms of districts, early post-birth daughter deficit is more equally distributed with Vellore accounting for

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17% followed by Dharmapuri, Dindigul, Villupuram and Salem, accounting for between 10 and 14% each. Overall, pre-birth daughter deficit dominates, accounting for (in this two-part classification) about 85% of the total shortfall of about 13,000 daughters per year. As discussed above, even if we were to use a three-part classification, the conclusion that in the 2000s the bulk (65%) of daughter deficit may be attributed to pre-birth deficit remains unchanged.

5 Conclusions

This paper highlighted variations in the problem of daughter deficit in Tamil Nadu which a national-level analysis often misses. A temporal examination of the SRB, IMR, U5MR and the 0-6 sex ratio showed that between 1981 and the early 2000s there has been a sharp change in the source of daughter deficit.

Based on a division of daughter deficit into pre-birth, early (age group 0-1) post-birth and late (age group 1-5) post-birth deficit, we found that between 1981 and 2001 the contribution of late post-birth daughter deficit declined sharply, while the share of pre-birth daughter deficit rose sharply. Analysis of district-level data on births and infant mortality showed that daughter deficit is not limited to isolated pockets but occurs in more than two-thirds of the rural areas of the state. Pre-birth daughter deficit seems to account for the bulk of the estimated shortfall, suggesting that sex selective abortion may be far more widespread than female infanticide. Additionally, the discussion here along with evidence on the decline in the 0-6 sex ratio in other states clearly supports the view that the diagonal divide in sex ratios and daughter deficit in India is no longer valid.

NOTES

- 1 Based on an expected SRB of 952 and expected rates of male infant and child mortality, the lower limit for the 0-6 sex ratio in populations without any pre- or post-birth interference should be 952.
- 2 Despite noting that areas with a normal SRB have "shrunk considerably in south India, as many districts in Karnataka, Andhra Pradesh and Tamil Nadu have crossed the threshold", Bhat and Zavier (2007: 2296), conclude that the SRB in south India is well within the normal range.
- 3 Previous papers on daughter elimination in Tamil Nadu include Soundarapandian (1985), George et al (1992), and Chunkath and Athreya (1997).
- 4 While there is no need to stop at age 5, the data suggest that mortality rates for boys and girls are not very different in the age group 5-9. According to Planning Commission (2002:233) even in 1981 and 1991, mortality rate in the age group 5-9 in Tamil Nadu was lower for girls (2.9 and 1.8 in 1981 and 1991, respectively) than for boys (3 and 2.4 in 1981 and 1991, respectively).
- 5 Countries include, Australia (2004) 944, Canada (2003) 952, Chile (2003) 955, France (2004) 951, Germany (2004) 949, Guatemala (1999) 965, Italy (2003) 946, Japan (2004) 950, Kazakhstan (2003) 943, Morocco (2001) 952, Netherlands (2004) 955, Poland (2004) 942, Romania (2003) 940, Spain (2003) 942, United Kingdom (2003) 951, and Venezuela (2002) 932.
- 6 Countries include, Australia (2004) 77, Canada (2003) 79, Chile (2003) 82, France (2004) 74, Germany (2004) 79, Guatemala (1999) 79, Italy (2003) 81, Japan (2004) 82, Kazakhstan (2004) 72, Morocco (2001) 83, Netherlands (2004) 71, Poland (2004) 77, Romania (2003) 72, Russia (2004) 72, Spain (2003) 80, United Kingdom (2003) 82, United States (2003) 76, and Venezuela (2001) 73.
- 7 Under 5 mortality rate is defined as the number of deaths by age 5 per 1,000 live births while the IMR is defined as the number of deaths by age 1 per 1,000 live births. Thus, the gap between the two provides information on the number of deaths between age 1 and 5 per 1,000 live births.
- 8 Other states are Arunachal Pradesh (rural-960, urban-980), Daman and Diu (rural-916, urban-943), Delhi (rural-850, urban-870), and Manipur (rural-956, urban-961).
- 9 If we work with IMR figures from SRS 1981 (Table 5, row 2), then the relative share of early and late post-birth deficit would be different with early post-birth deficit playing a larger role as compared to the estimates in row 1. Since we do not have SRS based estimates of U5MR we focus on the numbers in row 1.

- 10 NFHS-3 reports similar figures (see www.nfhsindia.org/nfhs3_national_report.html).
- 11 The assumption is extreme as the implication of a 20-per cent increase from the 0-1 sex ratio of 923 to a 0-6 sex ratio of 942, as in Table 5, row 6, is that under-5 mortality for males must be higher than under-5 mortality of females.

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