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Abstract

This paper measures the degree of inequality in child mortality rates across districts in India, using data from the 1981, 1991 and 2001 Indian population censuses. The results show that child mortality is more concentrated in less developed districts in all three census years. Further, between 1981 and 2001, the inequality in child mortality seems to have increased to the advantage of the more developed districts (i.e., there was an increasing concentration of child mortality in less developed districts). However, the inequality in female child mortality rates seems to have declined between 1991 and 2001, even as it increased – albeit at a slower rate than before – for male child mortality rates. In the decomposition analysis, it is found that while a more equitable distribution of medical facilities and safe drinking water across districts did contribute towards reducing inequality in child mortality between 1981 and 1991, different levels of structural change among districts were responsible for a very large part of the inequality in child mortality to the advantage of the more developed districts in all three census years. Other variables which played important roles in increasing inequality included a measure of infrastructure development, female literacy, and a social group status variable. The paper concludes with some brief comments on the policy implications of the findings.

Key words: inequality, decomposition, child mortality, districts, India.

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I. INTRODUCTION

Inequalities exist in the health sector – between the better and the worse-off. Reducing inequalities in health and mortality by socioeconomic status has been an important policy goal of many donor and international agencies [Gwatkin (2000), Wagstaff (2000)]. It is clearly important to know the determinants of these inequalities and how these determinants and inequalities change over time, especially with economic growth or retrogressions. In recent years, a number of studies have addressed these issues in the context of less developed countries [see, among others, Cleland et al. (1992), Victora et al. (2000), Wagstaff (2002), Nguyen and Wagstaff (2002), Zere and McIntyre (2003), Macassa et al. (2003), and Sastry (2004)]. Most of these studies, however, have either been based on survey data at a point in time or on surveys which have relatively short time gaps between them. An exception is the study by Sastry (2004) who presents trends in socioeconomic inequality in under-five mortality for Sao Paulo state in Brazil from 1970 to 1991, based on microdata from the survey component of the Brazilian population censuses that were conducted in 1970, 1980 and 1991. Unlike a number of other studies, Sastry does not find inequalities in health outcomes (in his case child survival) increasing with economic growth.

The purpose of the present paper is to measure the degree of inequality in child mortality rates across districts in India divided by their levels of economic development. We shall also attempt to decompose the causes of this inequality. We shall use data from the 1981, 1991 and 2001 Indian population censuses. The analysis will be based on 326 districts contained within 14 major states[1] and which together accounts for about 94 per cent of the total population of the country. The district is the basic unit of administration and the lowest level at which spatially disaggregated information on key demographic variables is available. The focus on districts, we believe, is of some importance in studying health outcomes in India, as district-level policies undertaken and implemented by district-level politicians and officials may often be of critical importance in determining these outcomes. Also, the influence of social norms – many of which have been undergoing rapid changes in India in recent years[2] – on child mortality, fertility, etc., is probably more adequately captured in district-level than in household-level analysis.[3] However, the district and household-level analyses are not, of course, contradictory and are best viewed as being complimentary.

Child mortality has been declining in India in recent years. The Indian census gives four estimates of child mortality, viz., the probability that a child will die before attaining the age of 1, 2, 3, and 5, respectively. These are based on census questions on the number of children ever born and the number of children surviving. The data are presented in the form of the number of deaths per thousand live births at these various ages and denoted as Q1, Q2, Q3, and Q5, respectively, and are available for 1981 and 1991 from the census authorities. However, the Office of the Registrar General and Census Commissioner have so far (at the time of writing) failed to provide these estimates for 2001. Fortunately, Rajan et al. (2008) for the Population Foundation of India have recently provided estimates of Q1 and Q5 for 2001 based on census questions on the number of children ever born and the number of children surviving, and we use these estimates for 2001.[4]

Child mortality, defined as the probability of dying by age of 5, registered a major decline between 1981 and 2001 – from about 157 per thousand in 1981 to 106 per thousand in 1991, to about 70 per thousand in 2001.[5] Female disadvantage in child survival (defined here as the excess of female deaths over male deaths by age 5) has been a major concern in India and of Indian demographic writings for a number of years.[6] This disadvantage, too, declined between 1981 and 2001, from 11.3 per thousand in 1981 to 6.4 per thousand in 1991, to 1.03 per thousand in 2001.

While a number of studies dealing with the determinants of child mortality and female disadvantage in child survival across districts are available in the literature,[7] none of these has addressed the issue of inequality. Is child mortality concentrated more in poorer than in richer districts? And if inequality does exist in the distribution of child mortality across districts, what specific factors account for this inequality? And how has the situation changed between 1981 and 1991, and between 1991 and 2001 when there was a major spurt in the growth rate of the economy?

In recent years, in health economics and related disciplines interested in inequality, the use of concentration index[8] has become quite common and in this paper we make use of the concentration index to address the above questions. The concentration index, like the Gini coefficient, is a relative measure of inequality which is derived from comparing an observed distribution of a variable across a particular socioeconomic dimension against a corresponding equal distribution. The main child mortality variable we shall use in this paper is the probability that a child will die before attaining age 5 years, i.e., we shall work with Q5 data.[9] However, as just indicated, the available data also enable one to construct variables for male and female child mortality rates separately as the data are given for male and female children separately and for the two sexes combined. Female child mortality – defined here as the probability of a female child dying by age 5 – is denoted by FQ5, and male child mortality – defined as the probability of a male child dying by age 5 – is denoted by MQ5. In the process of writing this paper, we had also, therefore, carried out inequality and decomposition analysis using data for male and female children separately (i.e., using FQ5 and MQ5 data) to see if there are any significant differences in the results for the two groups. The results of the decomposition analysis did not reveal any significant differences between the two groups and we shall not, therefore, report these results in the paper.[10] The inequality analysis, however, did reveal an interesting difference between the two groups and we shall note this at the appropriate place in the paper.

The plan of the rest of the paper is as follows. The next section, Section II, presents a brief discussion of the concentration index and the methods used to measure inequality in child mortality and decomposing the causes of this inequality. Section III discusses the data and provides a description of the variables used. Section IV presents the results. Section V concludes.

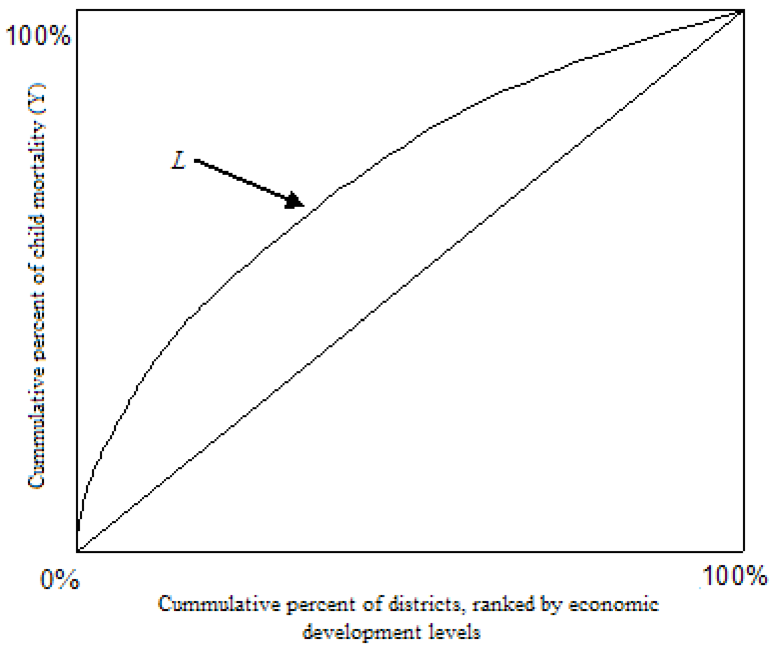
II. METHODS

In this section we provide a brief description of the concentration index and the formulae used for computing inequality in child mortality and decomposing the causes of this inequality.[11]

II.1 Measuring inequality in child mortality

Let y_i represent child mortality rate in district i, the variable in whose distribution by districts' economic development levels we are interested. In Figure 1, the curve labelled L is a concentration curve for y_i. It plots the cumulative proportion of child mortality against the cumulative proportion of districts ranked by their levels of

Figure 1. Concentration curve for child mortality



economic development, beginning with the least developed district. If the curve L coincides with the diagonal, all districts, irrespective of their levels of economic development, have the same value of child mortality rate (y). If, on the other hand, L lies above the diagonal, as in Figure 1, child mortality is typically higher amongst the less developed districts, while if L lies below the diagonal, child mortality (y) is typically higher amongst the more developed districts. The further L lies from the diagonal, the greater the degree of inequality in child mortality across districts grouped according to their levels of economic development. The concentration index, denoted by C, is twice the area between the concentration curve, L, and the diagonal, with values ranging from +1 to -1. A negative value for C when measuring inequality in child mortality, a negative outcome, shows inequality to the disadvantage of the less developed districts (higher rates of child mortality amongst the less developed districts). Conversely, a positive value of C shows inequality being to the advantage of the more developed districts.[12]

The concentration index, C, can be computed in various ways, one (Kakwani et al., 1997) being

$$C = \frac{2}{n\mu}\sum_{i=1}^{n} y_i R_i - 1 \qquad (1)$$

where μ is the mean of y (child mortality in our case) and R_i is the relative rank of district i. The districts are ranked by their levels of economic development, beginning with the least developed district.

The above computation, however, does not enable statistical inference: it is not possible to ascertain whether the calculated concentration index is statistically significant or not. To do so, a standard error for C can be calculated using a convenient regression as follows (Kakwani et al., 1997):

$$2\sigma_R^2\left[\frac{y_i}{\mu}\right] = \alpha + \beta R_i + \varepsilon_i \qquad (2)$$

where σ_R^2 is the variance of the fractional rank variable (the rank variable R in our case being the index of districts' economic development levels). In the above equation β is equal to the concentration index. The standard error of $\hat{\beta}$ approximates the standard error of C.

II.2 Decomposing the causes of inequality in child mortality

Turning to the decomposition analysis, it is natural to expect that inequalities in child mortality would reflect inequalities in the determinants of child mortality (such as, for example, the availability of medical facilities and safe drinking water). The question arises: what is the relative contribution of each of these various inequalities in explaining inequality in child mortality?

Let us suppose that the variation in y (child mortality) can be explained by a linear regression model with k determinants – x_k:

$$y_i = a + \sum_{k=1}^{m} b_k x_k + e_i \qquad (3)$$

where a and b_k are parameters to be estimated and e_i is an error term. It can then be shown (Wagstaff et al., 2003) that given the relationship between y_i and x_k in equation (3), the concentration index for y, C, can be written as:

$$C = \sum_{k=1}^{m}\left(b_k \cdot \frac{\bar{x}_k}{\mu}\right)\cdot C_k + \frac{GC_e}{\mu} \qquad (4)$$

where $\bar{x}_k$ is the mean of x_k, and C_k is the concentration index for x_k (defined analogously to C). The last term, which is computed as a residual, is a generalised concentration index for e_i and is defined as:

$$GC_e = \frac{2}{n}\sum_{i=1}^{n} e_i R_i \quad (5)$$

Equation (3) shows that C can be thought of as being made up of two components: the deterministic component $b_k \cdot (\bar{x}_k/\mu) \cdot C_k$ and a residual component GC_e/μ. In the deterministic component, $b_k \cdot (\bar{x}_k/\mu)$ is the estimated elasticity of y (child mortality in our case) with respect to x_k. The contribution of each x_k (explanatory variable) to explained inequality (inequality in child mortality in our case) is then derived by multiplying the elasticity component by the corresponding concentration index, C_k. Therefore, if the coefficient estimate b_k is not statistically different from zero, then the contribution of the particular k to explained inequality will also not be statistically significant. The residual component reflects the inequality that cannot be explained by systematic variation across districts' economic development levels in the determinants of y, the x_k variables.

III. DATA AND VARIABLE DEFINITIONS

Data for the analysis come from standard census sources and details are provided in Table 1. The measurement of inequality using the specification presented in Section II requires a variable which allows us to rank districts according to their levels of economic development. The ideal variable to use would be per capita district income. District-specific indicators of income or expenditure, however, are not available in India. While per capita income for the states can be easily computed from the available data, such data are not available for the districts. In order to overcome the problem of lack of suitable income data, we, therefore, decided to proxy a district's level of economic development by the share of agricultural workers in total workers (hereafter "agricultural workers" for brevity) in that district. A key element in the

Table 1. Variable definitions and sample means (standard deviations in parentheses), 1981, 1991 and 2001

Variable	Definition	1981	1991	2001
Q5	Probability that a child will die before reaching the fifth birthday ($\times 1000$)	156.82 (43.07)	106.85 (37.22)	69.38 (24.49)

FQ5	Probability that a female child will die before reaching her fifth birthday ($\times 1000$)	162.83 (48.50)	110.57 (40.88)	70.87 (25.82)
MQ5	Probability that a male child will die before reaching his fifth birthday ($\times 1000$)	151.55 (40.09)	104.20 (35.63)	68.08 (23.69)
Scheduled castes	Percent of a district's female population belonging to a scheduled caste	15.90 (7.07)	16.75 (7.02)	16.88 (8.10)
Scheduled tribes	Percent of a district's female population belonging to a scheduled tribe	9.01 (15.38)	8.99 (15.29)	9.62 (16.18)
Muslim	Percent of a district's female population whose household head is Muslim	9.76 (8.76)	10.51 (9.82)	11.19 (10.17)
Rural population	Percent of a district's female population living in rural areas	79.91 (15.14)	77.44 (15.75)	74.94 (17.84)
Agricultural workers	Percent of a district's main workers[1] aged 15 – 49 categorised as agricultural workers	68.08 (16.90)	67.21 (17.17)	57.70 (19.35)
Medical facilities	Percent of villages in a district having a medical facility	23.56 (21.80)	40.22 (29.87)	42.82 (25.01)
Pucca roads	Percent of villages in a district approached by pucca (surfaced) roads	41.88 (25.92)	47.82 (26.43)	63.26 (25.21)
Safe drinking water	Percent of households in a district with access to safe drinking water	34.76 (22.92)	60.48 (21.30)	98.50 (11.37)
Female literacy	Percent of a district's female population aged 15 – 59 that is literate	24.89 (17.17)	32.30 (18.54)	51.56 (17.51)
Female labour-force participation	Percent of a district's female population aged 15 – 49 categorised as main workers[1]	23.51 (16.84)	26.63 (17.06)	24.99 (13.07)
East dummy	Dummy = 1 for districts in the states of Bihar, Orissa, and West Bengal	0.18 (0.39)	0.18 (0.39)	0.18 (0.39)
West dummy	Dummy = 1 for districts in the states of Gujarat and Maharashtra	0.14 (0.35)	0.14 (0.35)	0.14 (0.35)
South dummy	Dummy = 1 for districts in the states of Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu	0.12 (0.41)	0.12 (0.41)	0.12 (0.41)

[1] In the Indian census, a main worker is defined as a person whose main activity is participating in an economically productive work by his/her physical and mental activities and who had worked for 183 days or more in the reference period (one year proceeding the date of enumeration).

SOURCES: Government of India (1988, 1997) and Rajan et al. (2008) for child mortality; Government of India (1989, 1994) for safe drinking water for 1981 and 1991. The remaining variables are calculated from Census of India 1981, Primary Census Abstract, Part II-B; Census of India 1981, General Economic Tables, Part III (A and B); Census of India 1981, General Population Tables; Census of India 1981, Social and Cultural Tables, Part IV; Census of India 1981, Series 1, Paper 3 of 1985, "Household population by religion of the head of household", Census of India 1981, District Census Handbooks; Census of India 1991, Primary Census Abstract, Part II-B; Census of India 1991, General Population Tables; Census of India 1991, Social and Cultural Tables, Part IV A-C2; Census of India 1991, Paper 1 of 1995 "Religion", Census of India 1991, Village Directory; Census of India 2001, Primary Census Abstract; Census of India 2001, General Population Tables; Census of India 2001, Social and Cultural Tables; Census of India 2001, General Economic Tables; Census of India 2001, Religion; Census of India, 2001, Tables on Houses, Household Amenities and Assets; and Census of India 2001, Village Directory development process is the systematic change that occurs in the economic structure with economic growth. The pioneering work of Clark (1940) and Kuznets (1966) demonstrated that economic growth is usually accompanied by a decline in the share of the agricultural sector in total output and employment. Agriculture represents a declining share of national output and employment because of both the relatively low income elasticity of demand for its products and the shifts in demand toward the products of other sectors, which are induced by changes in technology and in patterns of life and work associated with a growing economy. To capture these changes, the study includes as a variable the percentage of agricultural workers among all main workers in a district. Districts with higher percentages of agricultural workers, ceteris paribus, would have experienced less change in their economic structure and we use the variable agricultural workers to rank districts according to their levels of economic development.[13]

The decomposition of the causes of inequality in child mortality, as we have noted, is derived from a regression model which assumes that child mortality is linearly dependent on a vector of explanatory variables x_k. Definitions, means and standard deviations of the variables used in this paper are provided in Table 1. Detailed justifications for using these variables can be found in Bhattacharya (2006). In broad terms, the explanatory variables can be thought of as consisting of three groups. The variables in the first group are those designed to examine the impact of belonging to one of the three minority groups: scheduled castes, scheduled tribes and Muslims.[14] Those in the second group are designed to examine the role of women's agency. The variables in this group are female literacy and female labour-force participation.

The variables in the third group are designed to examine the impact of modernisation and the general level of development. The variables in this group are medical facilities, safe drinking water, pucca roads, a measure of rural-urban residence, and agricultural workers.

India is, of course, a vast country with diverse characteristics and to identify regional patterns, we also use three dummy variables: "East", for districts in Bihar, Orissa and West Bengal; "West", for Gujarat and Maharashtra; and "South", for Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. The control region consists of Haryana, Punjab, Madhya Pradesh, Rajasthan and Uttar Pradesh (the "North"). The "South", in particular, is generally considered to be more liberal than other regions in the country in such characteristics as marriage customs, kinship, and inheritance patterns. Women in the southern states are believed to have enjoyed a greater degree of freedom since the pre-Christian era.[15] Differences in cultural norms and values can, of course, have differing demographic consequences. Data on such measures as dowry and bride price practices, precise form of joint family systems, and inheritance patterns are not available through census or other macrodata sources.

IV. RESULTS

IV.1 Measurement of inequality

The average child mortality rates for 1981, 1991 and 2001 are presented in Table 2 by districts divided into quintiles according to their levels of economic development (in ascending order).[16] The results show, first, that, between 1981 and 2001, child mortality rates declined across all district quintile groups regardless of their levels of economic development (with the most developed districts recording the sharpest declines), and second, that there is an inverse relationship between child mortality rates and districts' economic development levels in all three census years.[17] Results for male and female child mortality rates separately are presented in the Appendix and they do not show any differences in trends for the two groups.

The concentration indices for child mortality rates are computed using formulation (2) in Section II. The indices for all three census years for all children and for male and female children separately are positive and statistically significant (Table 3). These results confirm the results in Table 2 and in the Appendix that there is inequality in child mortality rates among districts in India and that this inequality favours the more economically developed districts (i.e., child mortality is more concentrated in less developed districts). The results in Table 3 also suggest that there

Table 2. Distribution of average child mortality rate by districts' economic development levels – in quintiles, 1981, 1991 and 2001

Quintile	1981		1991		2001	
	Mean	95 % confidence interval	Mean	95 % confidence interval	Mean	95 % confidence interval
1 (least developed)	182.6	[172.7; 192.3]	130.8	[122.6; 138.9]	86.0	[80.5; 91.6]
2	177.4	[168.6; 186.2]	122.8	[113.2; 132.2]	78.1	[72.9; 83.3]
3	157.1	[147.8; 166.3]	104.5	[96.7; 112.2]	68.4	[63.9; 73.0]
4	144.8	[136.6; 153.0]	101.1	[93.3; 108.9]	67.1	[61.5; 72.8]
5 (most developed)	122.7	[112.7; 132.7]	75.6	[69.6; 81.6]	47.5	[42.7; 52.3]

NOTE: The child mortality variable is the number of deaths per thousand live births by age 5.

has been an increase in inequality in child mortality rates to the advantage of the more developed districts (i.e., there has been an increase in the concentration of child mortality in less developed districts) between 1981 and 2001: the concentration index for mortality rates of all children, for example, increases from 0.0824 in 1981 to 0.1024 in 1991, to 0.1075 in 2001.

Further analysis, however, shows that the changes are not statistically significant for any of the three groups.[18] However, it has to be remembered that there are only three data points here and that it is, therefore, perhaps not surprising to find that the changes are not statistically significant. What is interesting, however, is to note that the rate of increase in the concentration index between 1991 and 2001 has been slower than that between 1981 and 1991. Indeed, for female child mortality rates, the concentration index declined between 1991 and 2001, even as it was increasing – albeit at a slower rate than in the preceding decade – for male child mortality. This is also at a time when female child mortality rates had been declining faster than male child mortality rates.[19] However, before one jumps to the conclusion that the discrimination against female children is disappearing, one has to remember that female feticide has been a major feature of Indian demography in recent years and that the sex ratio (the number of females per thousand males) of the population in the age group birth to 6 years has registered a major decline from 962 in 1981 to 945 in 1991, to 927 in 2001. All one can say, therefore, is that the female children who are born now face less discrimination than before in terms of survival and that the degree of concentration of female child mortality rates in poorer districts may be weakening.

Table 3. Concentration indices for child mortality rate for all, male and female children

	All Children		Male Children		Female Children	
	Concentration Index	t-stat	Concentration Index	t-stat	Concentration Index	t-stat
1981	0.0824	4.36	0.0787	3.92	0.0868	4.67
1991	0.1024	4.41	0.0941	3.72	0.1151	5.37
2001	0.1075	5.00	0.1049	4.50	0.1090	5.38

IV.2 Regression results

For reasons already mentioned,[20] in the regression analysis and the decomposition results to be presented below, we concentrate only on mortality rates for all children (i.e., we work with Q5 data) and do not report the results of working with data on female and male child mortality rates separately. Table 4 presents the Ordinary Least Squares (OLS) estimates for child mortality rates for 1981, 1991 and 2001.[21] The elasticity components of the decompositions are derived from the coefficient estimates in Table 4. The results in Table 4 are also important in identifying which of the variables are statistically significant in the decomposition. As already noted, if the coefficient estimate of a particular variable is statistically insignificant, then the contribution of this variable to explained inequality will also be statistically insignificant.

Table 4 shows that the explanatory variables account for about 60 per cent of the variation in child mortality across districts in both 1981 and 1991, and about 56 per cent in 2001. The coefficients of safe drinking water, agricultural workers and the scheduled castes variables are statistically significant in all three regressions. The sign of safe drinking water is negative, showing that the increased availability of safe drinking water reduces child mortality. The sign of agricultural workers is positive, showing that a higher proportion of agricultural workers in total workers has a positive effect on child mortality. This implies, in other words, that the structural change in the economy (as reflected in a reduction in the share of agricultural workers) will lead to a decline in child mortality. The sign of the scheduled castes variable is positive showing that the scheduled caste status is associated with higher child mortality.

Table 4. Determinants of child mortality: ordinary least squares estimates for 1981, 1991 and 2001 *(Dependent variable: Q5)*

Explanatory variables	1981	1991	2001
East	-31.1680***	-32.9375***	-9.4420***
	(6.58)	(8.06)	(3.49)
West	-14.6434**	-23.1542***	-14.8013***
	(2.45)	(4.19)	(4.07)
South	-35.5109***	-35.4630***	-16.5449***
	(6.09)	(6.77)	(5.37)
Scheduled castes	0.6116**	0.5145**	0.5634**
	(1.99)	(2.15)	(3.88)
Scheduled tribes	-0.1644	0.3524***	0.3077***
	(1.28)	(3.16)	(4.18)
Muslim	0.8767***	0.4333***	0.0395
	(4.45)	(2.73)	(0.39)
Rural population	-0.5543***	-0.2332	-0.0259
	(3.26)	(1.48)	(0.46)
Agricultural workers	0.6000***	0.7977***	0.3163***
	(3.51)	(4.21)	(4.07)
Medical facilities	-0.4246***	-0.1353**	0.0391
	(3.82)	(2.21)	(0.65)
Pucca roads	0.0248	-0.3737***	-.1710**
	(0.22)	(4.17)	(-2.66)

Safe drinking water	-0.8390**	-0.3399***	-0.1539*
	(8.55)	(4.43)	(1.67)
Female literacy	-0.4132***	0.1698	-0.4005***
	(2.92)	(1.26)	(5.10)
Female labour-force participation	0.0268	-0.2861**	-0.0177
	(0.21)	(2.31)	(0.18)
Constant	206.5209***	117.8277***	92.8713***
	(13.11)	(8.01)	(8.21)
Adjusted R-Squared	0.6088	0.6022	0.5592
N	326	326	326

*Significant at 10%, **Significant at 5%, ***significant at 1%.

Of the other variables, the coefficients of pucca roads and scheduled tribes are significant in the estimates for 1991 and 2001, but insignificant in the estimates for 1981. The sign of the pucca roads is negative, while that of the scheduled tribes variables is positive in the estimates in which they are significant.

The coefficient of medical facilities is negative in all three estimates, significant in the estimates for 1981 and 1991, but insignificant in the estimates for 2001. The coefficient of the Muslim variable is positive in all three estimates, again significant in the estimates for 1981 and 1991, but insignificant in the estimates for 2001.

Of the women's agency variables, the coefficient of the female literacy is negative and significant in the estimates for 1981 and 2001, positive and insignificant in the estimates for 1991; that of female labour-force participation negative and significant in the estimates for 1991, but insignificant in the estimates for 1981 and 2001.[22]

So far as regional effects are concerned, all regional dummies are negative and significant showing that child mortality is lower in all regions compared to the control region.

IV.3 Decomposition results

We are now ready to present the results of the decomposition analysis (Table 5). We consider first the impact of modernisation and economic development variables.

Access to medical facilities has the effect of increasing inequality in child mortality to the advantage of the more developed districts (i.e., increasing the concentration of child mortality in less developed districts) in 1981 and 1991. Child mortality declines with access to medical facilities and districts with higher percentages of villages having a medical facility, as one would expect, are also the more economically developed. The contribution of the medical facilities variable to increasing inequality, however, declined between 1981 and 1991 and disappears in 2001 (statistically the elasticity component of the variable is not different from zero in 2001). In 1981, access to medical facilities accounted for around 20 per cent of inequality in child mortality to the advantage of the more developed districts. In 1991, this declined to around 6.4 per cent. This decline is a result of both the elasticity component of the medical facilities variable becoming smaller and medical facilities becoming more widely available across districts over time.

As with the access to medical facilities, access to safe drinking water has the effect of increasing inequality in child mortality to the advantage of the more developed districts. Child mortality declines with access to safe drinking water and households with safe drinking water are more concentrated in more developed districts. The contribution of safe drinking water to increasing inequality in child mortality also declined over time, from about 33 per cent in 1981 to about 8 per cent in 1991, to 2.7 per cent in 2001. This decline is largely a result of safe drinking water becoming more widely available across districts over time.

Table 5. Inequality decompositions for 1981, 1991 and 2001

	1981				1991				2001			
	Elasticity	Concentration Index	Contribution	Percentage Contribution	Elasticity	Concentration Index	Contribution	Percentage Contribution	Elasticity	Concentration Index	Contribution	Percentage Contribution
East dummy	-0.0366	0.2229	-0.0082	-0.1034	0.0567	0.2543	-0.0144	-0.1464	-0.0250	0.1641	-0.0041	-0.0378
West dummy	-0.0129	-0.0739	0.0010	0.0121	-0.0299	-0.1367	0.0041	0.0415	-0.0294	0.0333	-0.001	-0.0090
South dummy	-0.0479	-0.3541	0.0170	0.2153	-0.0713	-0.2832	0.0202	0.2048	-0.0512	-0.1942	0.0099	0.0915
Scheduled castes	0.0620	0.0173	0.0011	0.0136	0.0807	0.0065	0.0005	0.0054	0.1373	0.0061	0.0008	0.0077
Scheduled tribes	-0.0094	0.2235	-0.0021	-0.0268	0.0296	0.2529	0.0075	0.0761	0.0427	0.2929	0.0124	0.1150
Muslim	0.0546	-0.0192	-0.001	-0.0133	0.0426	-0.0344	-0.0015	-0.0149	0.0064	-0.0364	-0.0002	-0.0021
Rural population	-0.2824	0.0696	-0.0197	-0.2495	-0.1690	0.0806	-0.0136	-0.1382	-0.0281	0.0335	-0.0009	-0.0087
Agricultural workers	0.2605	0.1311	0.0341	0.4332	0.5018	0.1351	0.0678	0.6880	0.2631	0.1812	0.0477	0.4388
Medical facilities	-0.0637	-0.2376	0.0152	0.1922	-0.0509	-0.1229	0.0062	0.0635	0.0242	-0.1034	-0.0025	-0.0230
Pucca roads	0.0066	-0.1981	-0.0013	-0.0166	-0.1672	-0.1857	0.0311	0.3152	-0.1559	-0.0799	0.0125	0.1148
Safe drinking water	-0.1859	-0.1415	0.0263	0.3337	-0.1924	-0.0433	0.0083	0.0845	-0.2185	0.0133	-0.0029	-0.0268
Female literacy	-0.0656	-0.2495	0.0164	0.2076	0.0513	-0.2363	-0.0121	-0.1231	-0.2977	-0.1255	0.0374	0.3439
Female labour-force participation	0.004	0.0355	0.0001	0.0018	-0.0713	0.0779	0.0056	-0.0564	-0.0064	0.0736	-0.0005	-0.0043
Total			0.0789	1.00			0.1097	1.00			0.1086	1.00

NOTE: The elasticity components in this table are derived from the coefficient estimates in Table 4. The elasticity component is expressed as $\xi_k = b_k \cdot (\bar{x}_k / \mu)$, where b_k is the coefficient estimate on the variable k in Table 4, $\bar{x}$ is the mean of k, and μ is the mean of the dependent variable (i.e., child mortality in our case). For example, for 1981, the elasticity of the variable, say, agricultural workers is derived as follows: $\xi_{aw} = 0.6000 \times 68.08 / 156.82 = 0.2605$.

Concentration index for x_k, C_k, is derived from equation (2) in the text by replacing y_i with x_k and μ with the mean of x_k. The fractional rank variable R_i used to estimate the concentration index for total inequality in child mortality is retained in estimating all C_k s.

The contribution of each explanatory variable to explained inequality is then obtained by multiplying the elasticity component and the corresponding concentration index. Therefore, if the coefficient of the variable k, b_k, is not statistically different from zero, then the contribution of the particular explanatory variable to explained inequality will also not be statistically significant.

The availability of motorable feeder roads (pucca roads) connecting the villages to the highways is regarded as one of the important indicators of development by the India authorities.[23] While the elasticity component of the pucca roads variable is not statistically significant for 1981, for 1991 and 2001 pucca roads has the effect of increasing inequality in child mortality to the advantage of the more developed districts. Indeed, the pucca roads variable accounts for around 32 per cent of the explained inequality in child mortality to the advantage of the more developed districts in 1991, and while its contribution declines between 1991 and 2001, this still remains fairly high at 11.5 per cent in 2001. The decline in pucca roads' contribution is due mainly to a decline in the concentration index of the variable: pucca roads have become more widely available across districts over time.

The agricultural workers variable ("percent of a district's main workers categorised as agricultural workers") has the effect of increasing inequality in child mortality to the advantage of the more developed districts. Child mortality increases with the proportion of a district's population that is employed in agriculture. In 1981, the agricultural workers variable contributed to around 43 per cent of the explained inequality in child mortality. In 1991, this increased to a remarkably high figure of 69 per cent, before declining to a still impressive figure of 44 per cent in 2001. While the concentration index of the variable[24] rose between 1991 and 2001, the elasticity component declined and the effect of the decline in the elasticity component more than offset the effects of the increase in the concentration index. In so far as the share of agricultural workers in total workers reflect underlying structural features, the results for the agricultural workers variable would seem to suggest that differences in structural change among districts have been responsible for a very large part of the explained inequality in child mortality to the advantage of the more developed districts.[25]

So far as the women's agency variables (female literacy and female labour force participation) are concerned, the results show that female literacy has the effect of increasing inequality in child mortality to the advantage of the more developed districts in 1981 and 2001, but has no effect on inequality in 1991 (the elasticity component of the variable is statistically insignificant in 1991). Female literacy accounts for around 20 per cent of explained inequality in child mortality to the advantage of the more developed districts in 1981 and 34 per cent in 2001. While the concentration index of the variable declined over time, the elasticity component of the variable rose substantially to more than offset the effects of the decline in the concentration index. Female labour-force participation has no effect on inequality in 1981 and 2001 (the elasticity component of the variable is statistically insignificant in both years), but reduces inequality in 1991,[26] though the contribution is relatively small at about 5 per cent.

Of the social group variables, the scheduled castes variable has no significant effect on inequality in any of the years. Although the elasticity component of the variable is significantly different from zero in all three estimates, the proportion of women belonging to castes designated as scheduled castes is more or less equally distributed across districts divided by their level of economic development in all three census years: the concentration index of the variable is very close to zero in all three years. The scheduled tribes variable has no effect on inequality in 1981 (the elasticity component of the variable is statistically insignificant in 1981), but has the effect of increasing inequality in child mortality to the advantage of the more developed districts in 1991 and 2001 and this effect has increased over time (in 1991 the contribution of the variable to explained inequality was 7.6 per cent, while in 2001 this rose to 11.5 per cent). This increase is due both to the elasticity component and the concentration index of the variable increasing. Members of the scheduled tribes communities are being increasingly concentrated in less developed districts.

The Muslim variable, on the other hand, has the effect of reducing inequality in both 1981 and 1991. Muslim status in associated with higher child mortality rates in 1981 and 1991 and the Muslim population is more concentrated in more developed districts. The Muslim variable thus reduces inequality in child mortality by increasing child mortality in more developed districts. The effect, however, is very small – the contribution of the variable is a little over 1 per cent in each of 1981 and 1991, and disappears in 2001 (the elasticity component of the variable is statistically insignificant in 2001).

Finally, so far as regional effects are concerned, the “East” has the effect of reducing inequality in child mortality. Compared to the “North” (the control region), child mortality is lower in the “East” and more of the less developed districts are also concentrated in the “East”. However, the “East”’s contribution to reducing inequality in child mortality declined form 14.6 per cent in 1991 to around 3.8 per cent in 2001. The “South”, on the other hand, has the effect of increasing inequality in child mortality to the advantage of the more developed districts. Compared to the “North”, the "South" have lower child mortality rates and more of the more developed districts are also concentrated in the "South". However, the contribution of the "South" to increasing inequality in child mortality declined from 21.5 per cent in 1981 to 9.2 per cent in 2001. This is largely due to the decline in the relative concentration of the more developed districts in the "South". The "West"'s contribution to explaining inequality in child mortality has been quite modest in all three census years: the distribution of districts by their levels of economic development has remained more or less unchanged over time in this region. All in all, the regional effects would appear to be becoming weaker in explaining inequalities in child mortality.

V. CONCLUDING REMARKS

In this paper we have tried to measure the degree of inequality in child mortality rates across districts in India, using data from the 1981, 1991 and 2001 Indian population censuses. We have also attempted to decompose the causes of this inequality. We have found that while child mortality rates declined across all districts between 1981 and 2001, child mortality is more concentrated in less developed districts in all three census years. Further, between 1981 and 2001, the inequality in child mortality seems to have increased to the advantage of the more developed districts (i.e., there was an increasing concentration of child mortality in less developed districts). Though this last result was found not to be statistically significant, it has to be remembered that in the present study we had only three data points available. Once the relevant data from the 2011 census become available, it would be interesting to see whether or not the pattern persists and statistically significant results are obtained. However, we also found that the increase in the concentration index between 1991 and 2001, when there was a major spurt in growth rate of the economy, was slower than that between 1981 and 1991. Indeed, the concentration index for female child mortality rates declined between 1991 and 2001, even as it was increasing – albeit at a slower rate than before – for male child mortality rates.

In the decomposition analysis, we found that while a more equitable distribution of medical facilities and safe drinking water across districts did contribute towards reducing inequality in child mortality between 1981 and 1991, differing levels of structural change (as reflected in the share of agricultural workers in total workers) were responsible for a very large part of the inequality in child mortality to the advantage of the more developed districts in all three census years. Pucca roads – the infrastructure development variable in our model – also contributed towards increased inequality in 1981 and 2001. Of the women's agency variables, while female labour-force participation had no significant effects on inequality in 1981 and 2001, female literacy contributed towards increased inequality in 1981 and 2001.

It is also interesting to note that while the percentage contribution of female literacy to inequality increased, that of the agricultural workers variable declined between 1991 and 2001. A part of the explanation for this would appear to be the following. The influence of female literacy varies with the stages of economic development. The role of female literacy becomes more significant when a developing country experiences a first major spurt in the growth rate of the economy and the associated changes in society. The increased availability of health and other public infrastructures supporting child survival that comes with rapid economic development helps women to improve the survival chances of their children, and the literate women are better able to take advantage of these opportunities.[27] Further, in a buoyant economy, with more income earning opportunities opening up, literate women are able to improve their incomes relative to those who are illiterate and so are able to provide more support towards the survival of their children. The decline in the contribution of the agricultural workers variable to inequality during this period can also be related to economic growth. With the much greater availability of public amenities and infrastructures supporting child survival (such as the provision of safe drinking water, pucca roads, etc.), the level of income, taken on its own, loses some of its significance in directly affecting inequality.

Of the social group variables, the Muslim and the scheduled castes status had little or no effect on inequality in any of the three census years, but the scheduled tribes status was found to be increasingly becoming important in explaining inequality in child mortality to the advantage of the more developed districts. Members of the scheduled tribes communities are being increasingly concentrated in less developed districts. It is of some interest to note in this context that the current "Maoist" insurgency in India – which has been described by the Indian Prime Minister as the greatest threat to the national security – is occurring mainly in districts where the members of the scheduled tribes communities predominantly live. Clearly, targeted policies may be needed here. More generally, while policies of providing medical facilities, safe drinking water, and (schooling for) female literacy more equitably across districts should be continued, these by themselves would not be enough. It is also important to see that the benefits of both infrastructure and more general economic development are spread more evenly across districts. We did, however, find that the regional effects are becoming weaker in explaining inequalities in child mortality. In a previous study, one of us noted that the "South" was loosing some of its distinctive characteristics in determining demographic outcomes. The findings of the present study reinforce that view.

APPENDIX

Table A1. Distribution of the average male and female child mortality rates by districts' economic development levels – in quintiles, 1981, 1991 and 2001

	Male Child Mortality Rate					
	1981		1991		2001	
Quintile	Mean	95 % confidence interval	Mean	95 % confidence interval	Mean	95 % confidence interval
1 (least developed)	173.6	[164.5;182.8]	124.8	[116.4;133.2]	83.4	[78.2;88.7]
2	172.0	[163.6;180.3]	119.0	[110.0;128.1]	76.7	[71.5;81.9]
3	153.4	[145.0;161.9]	102.5	[95.1;109.9]	68.0	[63.4;72.6]
4	139.6	[132.1;147.2]	99.0	[91.3;106.8]	65.8	[60.5;71.2]
5 (most developed)	119.6	[110.3;128.8]	76.1	[70.1;82.0]	46.8	[42.1;51.4]
	Female Child Mortality Rate					
	1981		1991		2001	
Quintile	Mean	95 % confidence interval	Mean	95 % confidence interval	Mean	95 % confidence interval
1 (least developed)	192.5	[181.4;203.6]	139.2	[130.5;147.8]	88.8	[82.7;94.8]
2	184.3	[174.4;194.2]	128.5	[117.9;139.1]	79.5	[74.1;84.9]
3	161.2	[150.5;171.9]	107.6	[98.9;116.2]	69.2	[64.3;74.0]
4	150.7	[141.2;160.2]	103.4	[95.4;111.4]	68.8	[62.8;74.9]
5 (most developed)	126.0	[114.8;137.1]	74.7	[68.5;81.0]	48.5	[43.5;53.4]

Note: Male and female child mortality variables are the number of deaths per thousand live births by age 5 for male and female children, respectively.

NOTES

[1]The only major state missing is Assam, where no census took place in 1981. Three new states, namely, Chattisgarh, Jharkhand and Uttaranchal (since renamed Uttarkhand) were formed in the year 2000 carved out of the existing states of Madhya Pradesh, Bihar and Uttar Pradesh, respectively. For this study, therefore, the terms "Madhya Pradesh", "Bihar", and "Uttar Pradesh" refer to these states as they were before the formation of the new states, i.e., inclusive of districts that now constitute Chattisgarh, Jharkhand and Uttarkhand.

There were 326 districts in the 14 states studied in 1981, rising to 362 districts in 1991 (because 31 of the districts of 1981 had been split into two or more districts each) and then rising to 469 districts in 2001 (a number of the districts of 1991 had been split into two or more districts each). For this study, we merged each of the districts of 1981 that had been subsequently split, using the population of the relevant separate districts in 1991 and 2001 as weights. In cases where a district had been split between 1981 and 1991, we calculated the 1991 value of a variable for a particular district as a population weighted average over the relevant 1991 districts; similarly for the value of a variable for 2001.

[2] For a prescient intimation of these changes, see Naipaul(1990). See also Jensen and Oster(2009).

[3] On this, see the discussion in Drèze and Murthi(2001), p40 and Sen(1999), pp218-19.

[4] The method used by Rajan et al. yields slightly lower estimates of child mortality than does the method used by the census – the method used by Rajan et al. relies on procedures suggested by Pathak et al. (1998) which have the advantage of dispensing with the multipliers used by Brass (1975) and others. For a discussion, see Rajan et al., pp 2-3 – but as it yields lower estimates consistently across all districts, in analysing inequalities in child mortality rates across districts, this difference pose no particular problems.

[5] Child mortality rates at other ages also registered major decline during the period. Child mortality by age 3,2, and 1, for example, declined by about 40, 34 and 23 per thousand, respectively, between 1981 and 1991.

[6] See, for example, Agnihotri (2003), Bhattacharya (2006), Das Gupta (1987), Drèze and Sen (2002), Kishor (1993), and Sen (1999).

[7] See, among others, Bhattacharya (1999, 2006), Drèze and Murthi (2001) and Murthi et al. (1995).

[8] See Wagstaff et al. (1991).

[9] In the process of writing this paper, however, we also carried out inequality and decomposition analysis using Q1, Q2 and Q3 data for 1981 and 1991, and Q1 data for 2001 – it will be recalled that Q2 and Q3 data are not yet available for 2001 – but found no significant differences in results to those obtained with Q5 data. Results based on these Q1, Q2 and Q3 data are available on request from the authors.

[10] They are available on request from the authors.

[11] Our exposition in this section follows closely the discussion in Wagstaff et al.(2003) who were the first to present and apply the decomposition method that, following them, we employ here.

[12] The extremes of the range show absolute inequality and the mid-point, zero, absolute equality.

[13] In order to overcome the problem of lack of suitable income data at the district level, we had also toyed with the idea of generating district-level economic development indices by using factor analysis. However, in computing these indices we would have had to use a number of variables central to our regression analysis to

be presented below and this would have artificially biased many of our decomposition results. Nevertheless, as a check on our rankings of districts based on agricultural workers, we did compare our rankings with those that would be generated by using factor analysis [using the following variables, all of which capture aspects of economic development: rural population, pucca roads (properly surfaced roads), agricultural workers, medical facilities, safe drinking water, and female literacy]. Formal definitions of these variables can be found in Table 1 in the text. In the case of rural population and agricultural workers, it is, of course, the obverse of these variables, i.e., urban population and the share of non-agricultural workers in total workers which would be associated with economic development and in the factor analysis we used we did take account of this. The results were reassuring: rankings generated by using factor analysis were not that dissimilar to those generated using agricultural workers.

[14] Formerly known as "untouchables", a term applied to a wide range of Hindu groups belonging to the lowest rung in the caste hierarchy, the scheduled castes comprise about 16 percent of India's population, and they continue to suffer from persecution even though discrimination on the basis of caste was declared illegal in the Indian constitution. The scheduled tribes include most so-called tribal or indigenous communities throughout India. Considered to be outside the Hindu caste system, they comprise about 8 percent of India's population. Both scheduled castes and scheduled tribes are at the lowest level of the social scale. Muslims in India, who comprise about 11 percent of the population in the study area, are also considerably deprived in many dimensions.

[15] On these aspects, see, among others, Dyson and Moore (1983), Kolenda (1987), and Dommaraju and Agadjanian (2009).

[16] As already mentioned, economic development levels of districts have been proxied by the share of agricultural workers in total workers in a district.

[17] There is, however, no significant difference here between districts in quintiles 1 and 2. The 95 per cent confidence intervals for quintiles 1 and 2 intersect for all three years. This means a two-sided t-test with 5 per cent level of significance will not reject the null-hypothesis of equal mean child mortality rates for quintiles for the two least developed districts sub-groups.

[18] The 95 per cent confidence intervals for the concentration indices are [0.1335; 0.0607] in 1981, [0.1820; 0.0609] in 1991 and [0.0611; 0.1539] in 2001.

[19] The ratio of female to male child mortality declined from 1.07 in 1981 to 1.06 in 1991, to 1.04 in 2001.

[20] See p5 above.

[21] The standard errors of the coefficient estimates have been estimated using the Huber-White-Sandwich variance estimator to correct for any potential heteroskedasticity.

[22] The coefficient of rural population is significant only in the estimates for 1981. Its coefficient is negative all three estimates, thus suggesting that living in rural areas is associated with reduced child mortality. The important factor here, in fact, turns out to be the availability of safe drinking water. If the variable safe drinking water is dropped from the set of explanatory variables in these regressions (results of these regressions excluding the safe drinking water variable are available on request from the authors), then the coefficient of rural population is seen to become insignificant in the estimates for 1981, too. Urban areas are, of course, not necessarily healthier places to live than rural areas and these results would seem to suggest that if rural

areas are provided with basic health facilities, then living in rural areas is not a risk factor in child mortality.

[23] They facilitate communication to nearby towns, help commerce by facilitating the sale of agricultural surplus and import of manufactured goods, and also bring in the impact of outside events through delivery of such items as newspapers. They are important elements in the process of modernisation and important indicators of income earning opportunities.

[24] It may be noted that, given that we have used agricultural workers as the ranking variable to rank districts according to their levels of economic development, its concentration index can be interpreted as the Gini coefficient.

[25] The remaining economic development variable, rural population, is seen to have the effect of reducing inequality in child mortality in 1981, but has no effect on inequality in 1991 and 2001 (the elasticity component of this variable is statistically insignificant in both 1991 and 2001). Apropos of these results, see also the discussion in endnote 22 above.

[26] Female labour-force participation reduces child mortality in 1991 and female labour-force participation is also more concentrated in less developed districts.

[27] At still higher levels of development, with widespread availability of these facilities and good extension services, female literacy may, of course, become relatively insignificant in its impact.

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